REFERENCE OF MARINE ENGINEERING KNOWLEDGE FOR M.O.T 2nd Class Part B (Oral)

Compiled by Min Zar Tar

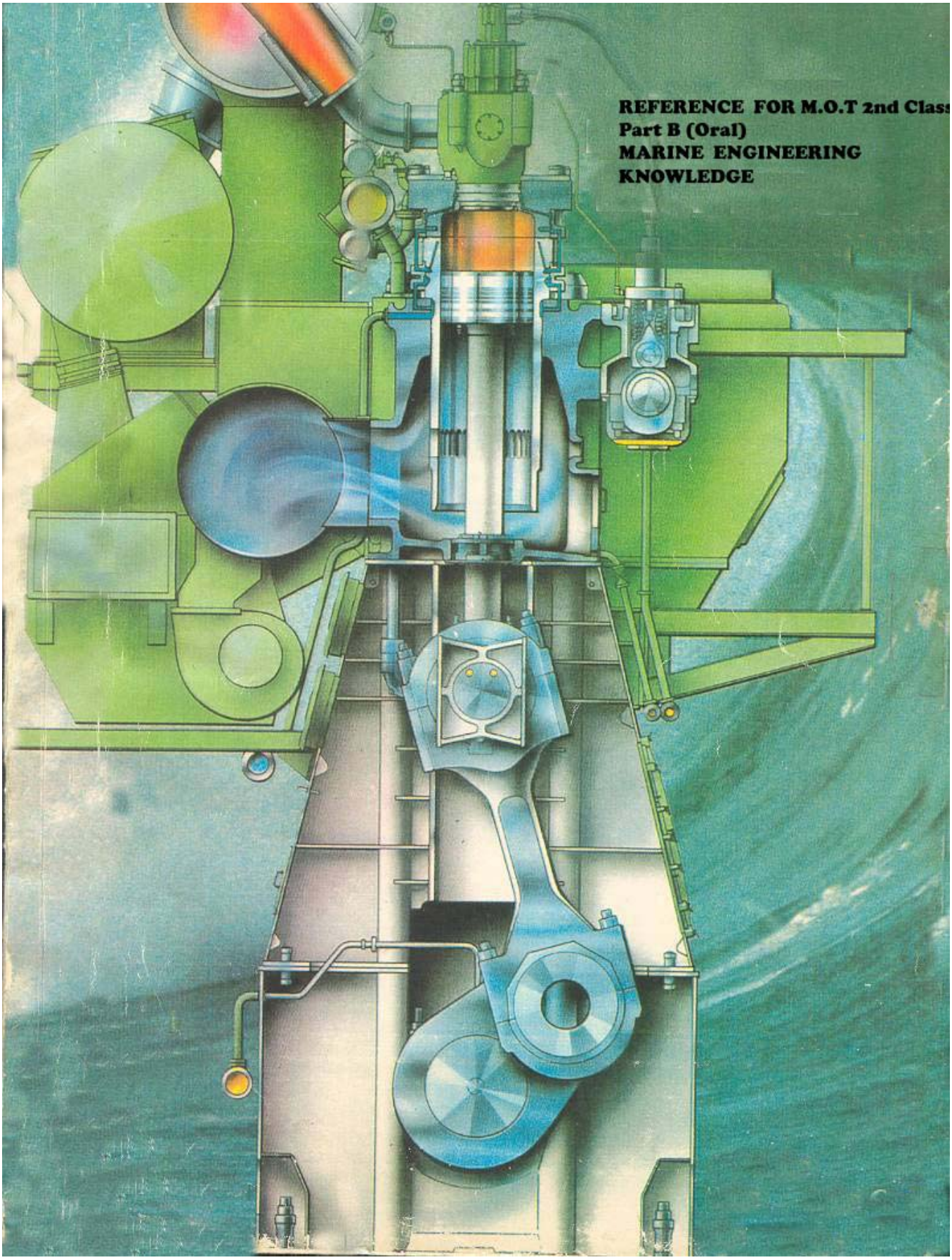


Table of Contents

INDICATOR DIAGRAM

What is the indicator diagram?

The diagrams indicating, simultaneously, the pressures and the relative position of the piston in the engine cylinder are known as indicator diagrams.

PURPOSE (WHY) OF TAKING INDICATOR DIAGRAMS

- **a)** Determining the indicated engine output
- **b)** Determining combustion (Pmax) and compression pressures (Pcomp)
- **c)** Evaluation of the combustion process and its peculiarities
- **d)** Evaluation of the exhausting and scavenging conditions

HOW TO TAKE INDICATOR DIAGRAM? (SQUENCE)

a) Check whether the spring fitted on the indicator instrument will meet the peak pressure to be expected (max. pressure of Engine).

b) Stretch diagram paper firmly over the drum.

c) Before taking diagram, open indicator cock, two or three firing strokes, to blow out soot and combustion residues in the cock.

d) After drawing atmospheric pressure line, hook the cord to indicator drive, open indicator cock, and take power diagram and shut the cock.

e) Remove hook, turn the drum by hand to a place clear from the power diagram, took compression pressure line with fuel cut-off.

f) Having taken indicator diagrams from all cylinders, open the indicator instrument and clean all parts especially the piston, thoroughly. After cleaning, apply high temperature grease into the surface of all parts.

Note: Do not allow the indicator instrument to become overheated by too many firing strokes, as it will affect the instrument accuracy.

Types of Indicator diagram?

⇨ Power card
⇨ Draw card
⇨ Compression card
⇨ Light spring card

What is indicated power? How to calculate power?

⇨ It is the power developed in the cylinder.
⇨ Firstly, take the power diagram for each cylinder
⇨ The area of the diagram can be measured by means of a planimeter.
⇨ Measures the length of diagram; check spring scale.
⇨ Calculate the mean effective pressure

$$M.E.P = \frac{\text{Diagram area}}{\text{Mean Length of diagram}} \times \text{Spring scale}$$

⇨ Record the engine revolution(RPM)
⇨ Calculate the power for each unit

I.P = MEP x Length of stroke x cylinder bore area x rps (Watts)
IP = P L A N x No. of Cyls (KW)

P = MEP (KN/m^2) = (Area of diagram / Length of diagram) x Spring scale
L = Stroke Length (m)
A = Cylinder bore area (m^2)
N = N for 2/S single acting (rps)
= N/2 for 4/S single acting
= 2N for 2/S double acting

Purpose of Each indicator diagram

Power diagram - To calculate indicate power. It also shows peak pressure.
In phase with piston movement, with fuel on.

Out-of-phase diagram - An out-of–phase diagram (draw card) is required to be taken if the compression pressure is to be accurately determined.

It shows Pmax (more accurately), P compression and ignition delay period (Nature of expansion curve). It also shows combustion process (early or late combustion)

To evaluate injection, ignition delay, fuel quality, combustion, loss of compression, expansion process, fuel pup timing, and after-burning.

90^{o} out of phase with piston movement, with fuel on, to determine Pmax

Compression diagram - To know compression pressure of the cylinder and cylinder tightness.
In phase and fuel cut-off.

Light spring diagram - This diagram are taken for determining the pressure variation in the cylinder during the exhaust and scavenging periods

The diagram shows-

→ Choke exhaust ports or valves
→ Loss of scavenge air

In phase, using light spring, with fuel on, to determine

When taken?

Taken at every month and after every major O/H on the way.
By according to the engine condition.

PRECAUTION NECESSARY TO AVOID INDICATOR MALFUNCTION

- ☞ *To reduce the effect of friction the indicator piston is removed, the piston and the cylinder cleaned and lubricated with a few drop of cylinder oil*
- ☞ *The tightness of the indicator piston in the cylinder should be checked. This can be done by dismantling the piston and allowing it to drop slowly through the cylinder by its own weight.*
- ☞ *The drum should not hit the stop at end positions. Play in the pencil mechanism will distort the diagram*
- ☞ *The cock should be free from accumulation of soot and oil*
- ☞ *The stylus should be adjusted to a light writing pressure*
- ☞ Before taking indicator diagrams, open indicator cock two or three firing stroke to *blow out soots and carbon residues in the cock.*
- ☞ *Check* whether the *spring fitted* on the indicator instrument will meet peak Pr: to be expected.

- ☞ Stretch *diagram paper* firmly over the drum
- ☞ After drawing atmospheric line, hook the cock to the indicator drive, open indicator cock and take power diagram, shut the cock
- ☞ Remove hook, turn the drum by hand to a place clear from power diagram, took compression pressure line with fuel cut-off
- ☞ Do not allow the indicator instrument to become overheated by too many firing strokes, as it will affect the instrument accuracy
- ☞ Having taken indicator diagrams, from all cylinders, open indicator instrument and clear all parts, especially the piston thoroughly.
- ☞ After cleaning, apply high temperature grease into surfaces of all parts

How to maintain good Performance

01) Maintain good power output per cylinder
02) Take power Card, to check power output/cylinder
03) Take Compression Card, to check for cylinder tightness
04) Check ratio of Absolute compression pressure to absolute scavenging pressure.
05) If the ratio is same as that during sea trial, piston rings and exhaust valves are sufficiently tight. (With B&W engine, this ratio is about 30)
06) If absolute pressure ratio is less, check for cylinder tightness, charge air cooler, scavenge air ports, scavenge valves, piston rings, exhaust valves, TC, etc.
07) Light spring diagram is taken if necessary
08) Check exhausts temperatures, exhaust smoke, load indicator and engine running parameters.
09) Check fuel, CLO & LO consumption
10) Regular maintenance works and repairs.

Absolute Pressure = Gauge Pressure (of Manometer) + Atmosphere Pressure (15 psi or 30 Mercuy)

In compression pressure is low:

- ✔ Carry out unit O/H and renew liner, piston and rings.
- ✔ TC checked, clean and overhauled, to have efficient operation
- ✔ Check Scavenge air line, charge air cooler, for insufficient scavenge air condition
- ✔ Check Inlet and Exhaust valves may be leaking.
- ✔ Clean Scavenge Ports, Scavenge Valves, if 2/S engine.

Early Combustion

Effects:

1) Very high peak pressure Pmax at about TDC
2) Lower Exhaust temperature
3) Increase Power
4) Increase Thermal efficiency
5) Heavy shock load to bearings
6) Engine knocking
7) Lower expansion line
8) Ignition occurs before TDC
9) Less S.F.O.C

Causes

1) Overheated piston
2) cetane number of fuel than normal

3) Fuel injection pump plunger has been set too high (Incorrect fuel pump timing or wrong V.I.T setting)
4) Incorrect adjustment of the fuel cam on the camshaft
5) Incorrect adjustment of fuel valve spring pressure (low)

LATE IGNITION

Effects:

1) Lower peak pressure
2) Higher Exhaust temperature with black smoke
3) Loss of power
4) Reduced Thermal efficiency
5) Reduced Scavenge efficiency
6) Higher Exhaust gas pressure at blow down period and increasing pulsation in the exhaust manifold
7) Higher expansion line
8) Ignition occurs after TDC
9) Increase S.F.O.C

Causes

1) Incorrect fuel pump timing and wrong V.I.T setting
2) Faulty fuel valve (Excessive injector spring setting)
3) Injection viscosity too low
4) Lack of scavenge air or cold air
5) Bad atomization
6) Slack chain drive
7) Lower cetane number of fuel
8) Worn out fuel pump, cam and roller
9) Low compression
10) Under cooling of parts within the cylider
11) Leaky fuel pump delivery valve or spill valve
It may cause:
- **a)** Exhaust valve burning
- **b)** Turbocharger surging
- **c)** Fouling of exhaust system
- **d)** Uptake fires
- **e)** High cylinder temperature resulting in liner lubrication difficult.

After Burning

Symptoms & Effects

1) Rise in expansion line during latter part of the load
2) Exhaust temperature and Exhaust pressure will be high, with burning fuel and carbon passing to exhaust.
3) This may burn exhaust valves and foul the exhaust system, with risk of T/C surging or uptake fires.
4) High temperatures within the cylinder cause deterioration in lubrication and possible damage to liner surface & piston rings. This may be the cause of piston crown burning.
5) Smoky exhaust

Causes

1) Incorrect fuel pump timing (Slow or late combustion of fuel)
2) Faulty fuel injector (leaky fuel valve)
3) Heavy fuel oil temperature too low and high viscosity
4) Lack of scavenge air
5) Poor compression
6) Poor quality fuel

EXHAUST VALVE OPENING

Exhaust valve opening in a slow speed engine can be checked by means of light spring indicator diagram.

Early opening

1) Indicates high exhaust temperature with the risk of overheating and contamination
2) Causes a loss of power since pressure is released too soon.

Late opening

1) Reduces the scavenge efficiency by reducing blow down
2) Affects the supply of energy to the turbocharger.

CHOKE EXHAUST PORTS OR VALVES

Symptoms

1) Higher exhaust pressure with sooty smoke
2) Higher mean temperature of working parts
3) Higher Exhaust temperature with heavy smoke
4) Lower Pmax , Lower Pcomp
5) Loss in power
6) Surging of Turbocharger

Earlier Exhaust

- ☆ Sufficient time for Cyl: Press: to fall below charge air press . When the scav Ports uncovered.
- ☆ Increased pulse energy available from the exhaust gas which can be used to improve pulse T/C performance.
- ☆ By advancing exht Timing, Gain in T/C output is greater than loss of expansion stroke.

Causes

1) Faulty fuel injection system
2) Lack of scavenge air
3) Excessive cylinder lubrication
4) Fouling of exhaust system

Remedies

- 🛠 Correct fuel timing and fuel injection system
- 🛠 Maintain scavenging system in good order
- 🛠 Correct cylinder lubrication feed
- 🛠 Clean exhaust grid and Turbocharger

CHOKED FUEL VALVE

Symptoms

1) Loss in engine power
2) Hammering in the fuel pipes between fuel pump and injector (This may lead to rupture of fuel pipe)
3) Reduce exhaust temperature
    a. It can be confirmed by indicator diagram power and draw cards. The diagrams show
    b. irregularities at the peak of the diagram.

Causes

4) The contamination in the fuel in which debris may choke the small atomizer holes in the injector
5) A leaky injector allowing hot gas to blow back into the injector causing carbon to form and choke the injector.
6) Overheating of injector nozzle may also cause build-up of carbon.

Remedies

- Change the fuel valve
- Clean the whole fuel system
- Ensure correct centrifuging and filtering of fuel
- Maintain correct cooling temperature of fuel valve

LEAKY FUEL INJECTORS

Symptoms

01. Loss in power
02. High Exhaust temperature with smoke
03. Knock or pressure wave in fuel injection system

It can be detected by taking both Power card and Draw card, which shows fluctuation of pressure during the expansion process due to secondary burning of fuel leaking from the valve.

It may **cause:**

a. Afterburning
b. Hot gas from combustion chamber blow past into the injector and forming carbon trumpets choking the injector
c. Fouling and loss efficiency of turbocharger due to afterburning
d. Coking of exhaust ports and grids.

Diagram showing leaking injector

Remedies

- The fuel valve should be renewed and tested for faults and rectified.
- Fuel purification and separation system should be kept in good order
- Fuel system temperature and Nozzle cooling temperature must be maintained in correct levels.

LEAKY PISTON RINGS OR WORN LINER

Symptoms

1) Loss in engine power
2) Lower compression (Pcom) and combustion (Pmax)
3) High exhaust temperature with smoke

Causes

1) Excessive cylinder liner wear

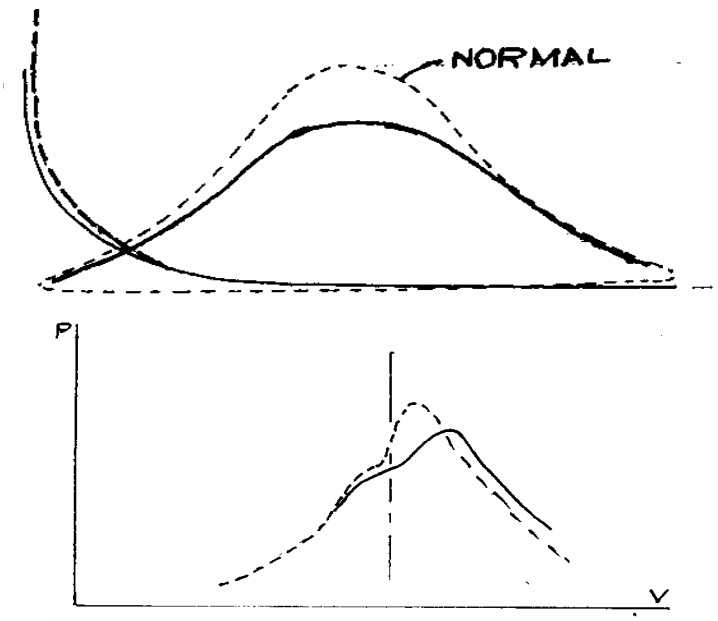
2) Lack of cylinder lubrication
3) Worn, broken, stuck or poorly maintained piston rings
4) Worn piston ring groove landings allowing rings to cant and jam
5) Carbon jamming rings in grooves
6) Turbocharger failure due to fouling
7) Blockages in the exhaust gas system.

It can be detected by taking Draw card which shows higher dip in compression line. It may cause:

(1) Blow past of combustion gas
(2) High rate of cylinder liner wear due to poor cylinder lubrication
(3) Scavenge fire
(4) Piston seizure due to local overheating

Remedies

- Renew cylinder liner if necessary
- Overhaul piston
- Clean ring grooves and gauge
- Machine or fit new groove inserts as necessary
- Renew piston rings with correct clearances
- Maintain cylinder lubrication and avoid overload



Leaking piston rings

Cetane Number

- A measure of ignition quality of fuel
- The higher the Cetane Number the shorter the time between fuel injection and rapid combustion
- The higher the Cetane No. the better the ignition quality
- Considered as poor fuel, if C< 37 Usual range is 30-45

High Cetane Number Effects

1. Shorter delay period
2. Early combustion
3. Increased power
4. Knocking

Low Cetane Number Effects

1. Longer delay period
2. Late combustion
3. Decreased power
4. After burning
5. High exhaust temperature and smoke

Diesel Knock

Violent knocks produced by high *rate of pressure rise*, RPR, during combustion, as delay period is *longer* then normal

Causes

1. Too low working temperature
2. Cold start
3. Too early fuel injection

Calculate the indicted power diagram by Mid ordinate Method

Calculate mean height of diagram = $\frac{\text{Sum of mid ordinates}}{\text{Number of parts in diagram}}$

Calculate MEP = Mean height of diagram x Spring scale

LUBRICATING OIL

(1) Function of a lubricant ? *****

01) Separate entirely the working surfaces, thus reducing static and dynamic friction to a minimum and preventing wear.
02) Remove heat, generated either within the bearing or from an out side source.
03) Protect against corrosion
04) Flush away contaminants.
05) Dampen noise.
06) In some case; act as a sealant.

(2) Types of Lubrication

Hydrodynamic	- Full fluid film lubrication.
Boundary	- Thin film lubrication
Hydrostatic	- Thick film lubrication
Elasto-hydrodynamic	- Thin film or square film lubrication.

(3) Properties of crankcase lube oil ?

(a) Viscosity (Suitable)	(b) Viscosity index (Hight)
(c) Pour Point (low)	(d) Flash point (high)
(e) Oxidation stability	(f) Carbon residues (low)
(g) Total acid number (TAN)	+ Total basic number (TBN)
(h) Detergency	(i) Dispersancy

(4) What is viscosity

⇨ A measure of its internal resistance to flow.
⇨ Viscosity of oil changes with temperature, falling when temperature rises and vice versa.
⇨ Crankcase L.O – 130 to 240 seconds, Redwood No-1 at 60°C.
⇨ For cylinder oil, viscosity is 12.5 – 22 Cst

(5) What is viscosity index ? (VI)

(1) The rate of change of viscosity of an oil in relation to change of temperature.
(2) Low viscosity index has greater change of viscosity with change in temperature than the oil of high VI.
Good crankcase oil = VI scale is 75 to 85.
For cylinder Oil, VI is 85
(3) Highest VI of mineral oils is about 115 and with special additives, this may be raised to about 160
(4) Hydraulic oils, used in **remote control hydraulic circuits** must have very high VI; otherwise *erratic response* to the controls can be troublesome (Telemotor hydraulic system oil has VI of 110)

(6) What is a pour point ?

(1) It's the lowest temperature at which an oil will barely flow.
(2) Pour point indicates that oil is suitable for cold weather or not.
(3) Pour point of engine crankcase should be -18 °C

(7) What is the flash point ? ***

It is the lowest temperature at which the oil will give off a sufficient inflammable vapour to produce a flash when a small flame is brought into the surface of the oil.

Close flash point for crankcase LO is around 220 °C.

Why flash point is important ?

FO ⇨ It is important, fuel oil flash point is to be fairly high because of they were low, there would be a possibility of fire in storage.

LO ⇨ Engine crankcase oil flash point should be as high as possible to prevent crankcase explosion.

(For safe storage) to limit the oil storage tank heating temperature at least 14 °C lower than its F.P prevent fire.

Average Closed Flash Points

Petrol	= -20 °C	70cSt Fuel Oil	= 71 °C
Paraffin	= 40 °C	Lube Oil	= 220 °C
Diesel Oil	= 65 °C		

(8) What is TAN and TBN ?

It is the neutralization value of used engine lube oil.
The ability of an oil to react with a base reagent which indicates the acidity expressed as **TAN**.
The ability of an oil to react with acidic reagent which indicate the alkalinity expressed as **TBN.**

The results are expressed intern of milligrams of potassium hydroxide (KOH) required to neutralise one gram of sample oil for both TAN and TBN.
TBN for an oil used for

Crosshead type diesel engine crankcase is	8mg KOH/gram of oil.
For trunk type engine using heavy oil is	30mg KOH/gram of oil.

(9) What type of engine are using high TBN and why ?

At trunk type engine using heavy fuel oil if blow pass occur incomplete combustion products reach directly into the crankcase and may cause the contamination with acid easily. Thus in this type of engine to neutralize the acid contamination must be used high TBN oil.

(10) What are detergency / dispersancy ?

It is a chemical compound called detergent which has property of preventing the deposition of carbonaceous deposit and wash away with the lube oil.

Dispersant additive addition is made to divide the larger size deposits into tiny particles to be carried in a colloidal suspension evenly throughout the bulk of oil.

(11) Explain the L O sampling procedure to send for LO test ?

The sample should be drawn with oil circulation with the system such as a test cock on the discharge side of the LO oil pump.

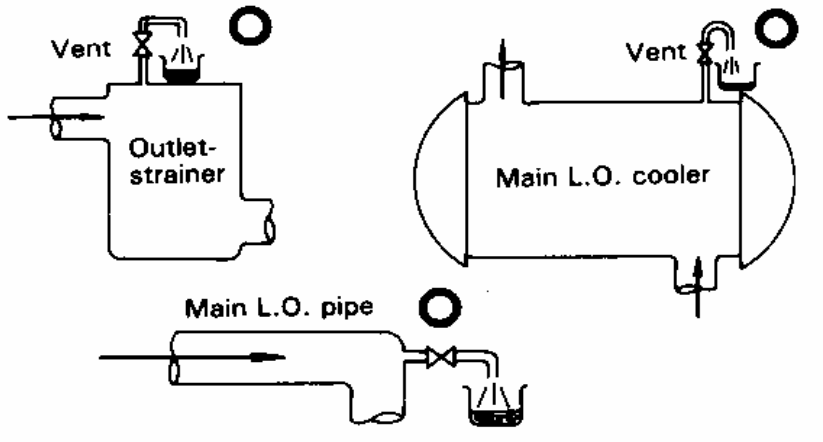
Before taking the sample oil sufficient amount of oil should be drain out to clear the line.

The sample is filled into the chemically cleaned container after it is rinsed with the sample oil and immediately closed.

The container should be attached **1)** engine type **2)** engine running hours **3)** LO running hours **4)** fuel used **5)** draw off point and **6)** date.

Sampling Procedure

Draw samples from a connection that comes directly out of the main oil supply line to the engine. Always sample for the same point. Sample only when the oil is up to its operating temperature with the engine running.



Depending upon the draw off point, sufficient amount of oil should be drained out of the line prior to drawing the sample. The sample should be filled into a chemically cleaned container after it is rinsed with sample oil and immediately closed. The container should be attached with a label as follows:

Records for Sample

(1) Date of sample drawn
(2) Point of sample drawn
(3) Type of oil
(4) Type of machinery use
(5) Temperature of sample drawn
(6) The period of time since the last renewal of oils.

Avoid

- Sampling form places where the oil may be stagnant or have little or no flow, such as:
  - Sumps
  - Auxiliary smaller pipelines
  - Purifier suction or discharge lines.
  - Drain cocks of filters, coolers etc.
- Sampling while engine is stopped

(12) Essential factor effecting the establishment of hydrodynamic lubrication ?

*****

01) Viscosity of oil
02) Load acting on the bearing
03) Surface smoothness of moving parts
04) Speed of rotating
05) Continuous LO supply
06) Bearing clearance, bearing length and pin diameter.
07) There must be convergence between fixed end and moving surface.

(13) Where do locate ME LO sump and its fitting ?

It is located under the engine in the ship double bottom and surrounded by cofferdams.

It consist of **1)** level gauge **2)** man holes **3)** air vent pipe **4)** sounding pipes **5)** heating steam coils **6)** suction pipe and **7)** valves for LO p/p and purifier.

(14) Why magnetic fitter is fitted on LO system ? Where fitted ?

- ⇨ To prevent pump damage due to ferrous metal particles.
- ⇨ Screw p/p used in LO oil system is working in very fine clearance thus to prevent entering the small ferrous particles into the p/p.
- ⇨ Magnetic fitter is fitted prior to the main circulation LO p/p.

(15) Contaminants in the lube oil ?

a) Contamination of fresh Water (JW leaking)
b) Contamination of SW (Cooler leakage)
c) Contamination of fuel (Poor Atomisation, Unburned Fuel)
c) Oxidation products (High Exhaust Temperature, Burned Cyl Oil, Carbon from incomplete combustion)
d) Products of fuel combustion
e) Foreign mineral matters (Scale formation, Wear and tear)
f) Bio logical contamination.

(16) Water contamination in lube oil ?

Causes 1) condensation of water vapour within the crankcase
2) Leakage from the cooling water system for cylinder or piston
3) Leakage from the sump tank heating steam coils.

Effects - Reduce cooling efficiency.
- Increase the acid formation in trunk type piston engine.
- Can cause corrosion on m/c parts.
- Microbial degradation, [Reduce centrifuging efficiency; promote local pitting and corrosion]
- Reduce load carrying capacity
- Reduce L.O properties, and TBN of oil
- Form sludge due to emulsification

Remedies - Proper purification with minimum throughput
- Batch purification if heavy contamination

Maximum Allowable % of water in LO

For crosshead engine, < 0.2 % is satisfactory
If water content exceed 0.5 ~ 1.0 %, immediate action should be taken
If > 1%, engine can be damaged

For trunk type engine, < 0.1% is satisfactory
If > 0.5 %, immediate action should be taken and
It is maximum permissible content

(17) Fuel dilution in lube oil ?

Causes ⇨ Poor atomization of a fuel injector and back leak through the fuel injector p/p plunger and barrel.

Effects ⇨Fuel dilution usually diesel oil.
⇨Lower viscosity and low fresh point
⇨Lower viscosity LO reduces this properties (e.g load carrying capacity)
⇨Lower fresh point will case crankcase explosion.

How to move contaminants

Filtering	- Removed large oil insoluble matter
Gravity separation	- Heavy matters, sludge and water
Adding special additives	- Reduce acids, sludge, finer oil insoluble matter
Centrifuging	- Sludge, foreign matter and water
Water washing	- Only for straight mineral oil or oil without additives, can remove acids.

What will you do if LO is contaminated with FW or SW ?

(1) Batch Purification must be done
(2) Renovating Tank heating and regular draining
(3) For SW contamination, Water Washing is required
(4) Sump to be opened and thoroughly wipe out.

(18) How do you make batch purification ?

- ⇨ Firstly take the immobilization permit from the port authority.
- ⇨ The entire oil charge should be pumped by the purifier or by main circulation p/p into renovating tank.
- ⇨ It should be allowed to settle for at least for 24 hours with heating about 60°C (60°C).
- ⇨ Water and sludge should be drained out periodically.
- ⇨ Cleaned the interior of the sump tank and carefully examined.
- ⇨ The oil should be passed through the purifier at its optimum efficiency and than pump back into the sump tank.
- ⇨ When sump tank empty, its interior should be cleaned and exaimed.

(19) When periodic batch purification make ?

- ⇨ If the oil is suspected from containing strong acids,
- ⇨ High insoluble contents due to poor combustion or water due to leak cooling system.
- ⇨ It is also made at least once a year when cleaned and examined for sump tank.

(20) What is grease ?

- ⇨ It is a semisolid lubricant consisting of high viscosity mineral oil and metallic soap with filler.
- ⇨ Metallic soaps are compound of Ca, Na, Al.
- ⇨ Filler are lead, zinc, graphite and molybdenum.

(21) What is solid lubrication ?

- ⇨ Grease lubrication

(22) At what point will feed to the piston ?

- ⇨ The cylinder oil is feed to the piston at the time when the top two piston rings pass the lubrication holes in the cylinder during the piston stoke.
- ⇨ It is a limited lubrication.

(26) What will be happen temp: is lower than pour point ?

The oil can not freely flow thus effect the pumping system (lubrication system)

(27) Why viscosity is important ?

FO ⇨ Low viscosity is required for fuel in order to obtain good atomization at fuel valve.

LO ⇨ LO must be chosen which has a suitable viscosity for the working temperature for efficient lubrication.

(28) How to maintain L.O on board ? ******

(1) L.O onboard test is carried out regularly.
(2) Regular cleaned L.O line filter.
(3) L.O purifier should be run during ship is in sea
(4) Maintain L.O purifier performance
(5) Periodic batch purification must be carried out & cleaned L.O sump tank once a year
(6) Maintain L.O temperature within receptacle limit
(7) Maintain good L.O cooler efficiency
(8) Keep good fuel combustion system

(29) Why cooler is installed after filter ?

It is more effective to filter the hot oil, as pressure drop through the filter is less and filter is more complete.

(30) Action of L.O temperature abnormally high (What will you do as 2/E, if M/E L.O temperature abnormally high) ********

(01) Inform bridge & reduce engine speed ⇨ **Quick response**
(02) Check engine overload or not (Exhaust temp:, fuel rack,..)
(03) Check L.O sump & L.O cooler & L.O purifier temperature (set value)
(04) Check L.O sump tank heating valve.
(05) Shut L.O cooler by-pass totally after stopping (or) too high temperature not fall
(06) Clean L.O cooler
(07) Check sump tank heating coil leakage
(08) Make L.O onboard test (esp Viscosity)
(09) Check L.O piping system leakage or blockage
(10) Make (inspection & check bearing clearance & loosing attachment
(11) Check ampere (or) load when turn the turning gear

(31) Action when increase L.O level

(01) Check piston cooling system (water)
(02) Check L.O purifier (gravity disc is correct or not) [L.O purifier water outlet sight galss]
(03) Check filling valve from storage tank
(04) Check L.O cooler/although oil pressure is greater than S.W pressure.

(32) Action when decrease L.O level

(1) Check rate of decreasing if slowly decrease, fill up L.O and find the leakage without stopping engine

(2) If rapidly decrease, inform to bridge and stop the engine. Find the leakage and repair. Possible leakage points:
- **(2a)** Bed plate crack (check engine room bilge)
- **(2b)** Piston cooling L.O system (check scavenge space & under piston space {entablature})
- **(2c)** L.O cooler & L.O purifier
- **(2d)** All pipes and connection

(3) Check L.O return valve from crankcase to sump tank close or not

(4) Check oil scraper rings & stuffing box

(33) Action when decrease L.O pressure

1. Start stand by pump
2. Change & clean L.O filter
3. After engine stopping, check bearing clearance and L.O pipe connection
4. Check L.O pump discharge & suction pressure
5. Check L.O temperature

Hydrodynamic lubrication (full fluid film)

(1) Moving surfaces are separated completely by the pressure of a *continuous unbroken film* or a layer of lubricant, generated by the movement of the two surfaces relative to each other.

(2) Essential requirement is formation of a wedge of lubricants between surfaces.

(3) Thickness of film 0.025 – 0.10 mm.

(4) Lubrication for Journal Bearing, Bottom End Bearing, Tilting Pad Thrust Bearing

Boundary lubrication

(1) It exists when a full-fluid film lubrication is not possible.

(2) The sliding surfaces are separated by only a thin film of lubricant.

(3) High friction between the surfaces and some degree of metal to metal contact occurs

(4) Lubricant oil film decreases, until asperities of mating surfaces touch

Hydrostatic lubrication

(1) A form of thick film lubrication, but instead of being self- generated, it is supplied from an external source by oil under pressure from a pump.

(2) Lubrication for Crosshead Bearings, with attached pump.

Elasto-hydrodynamic lubrication

(1) Applies to line contact or nominal point between rolling or sliding surfaces, such as rolling contact bearings and meshing gear teeth.

(2) Thin film or squeeze film lubrication limits metal to metal contact.

(3) Elastic deformation of the metals occurs, and there is effect of high pressure on the lubricant.

If LO is contaminated with SW

1) When sump oil is contaminated with SW, find sources of leakage (may be from LO cooler during ME stopped) stoppage and rectified

2) In port or while ME is stopped, transfer contaminated oil through purifier or transfer pump into Renovating Tank, settled for at least 24 hours at about 60°C, and water and sludge drained out periodically

3) Oil passed through purifier at 78°C with optimum efficiency, and pump back to Renovating Tank

4) When sump tank is empty, interior cleaned and examined

5) Purified oil sent to laboratory and tested
6) During this time, new oil should be used
7) Oil should be reused, if lab results recommended that it is fit for further use. (Straight mineral oil 3% water washed. Additive oil1% water washed)

Difference in Cylinder oil and System oil

- ⇨ Cylinder oil is detergent / dispersant oil
- ⇨ System oil is straight mineral oil

L.O on board test

Viscosity Determination

The simplest method is three tube rolling ball viscometer

Assuming the oil in the engine to be SAE 30 grade, one tube is filled with minimum safety viscosity (about SAE 20) and another one filled with maximum safety viscosity (about SAE 40). The last tube is to be filled with test sample.

All tubes are placed in a bucket of warm water until the oils are at the same temperature. The three tubes then mounted on a tilted board and inverted. An internal hollow ball in each tube then rises to the surface.

If the time taken in the test sample is between that of the lower and upper limit oils, the oil is fit for further use. If not, it must be replaced.

Insoluble Content

A drop of sample oil is released from a given height onto a special filter paper. Compare the result with the known varying insoluble content. The upper limit for straight mineral oil is 1% to 1.5 % and for detergent dispersant oil is 5%.

Water and other Contaminants

A known amount of sample oil in the test tube is heated and must be shaken the while doing so

1) If there is no cracking, the oil is dry
2) If there is slightly cracking, the oil having a trace of water
3) If there is a heavily crackling, the oil is heavily diluted with water

Acidity / Alkalinity Determination

Acidity is tested by extracting the acids from the sample by means of shaking with a known amount of distilled water. The acidic extract is then placed on a watch glass with an indicator solution of known strength. The mixture is then drawn up into a glass tube and its colour compared with a series of colour standards, each representing a known PH value, from which the sample can be determined quite accurately.

Another method is:

A drop of indicator solution is placed on to blotting paper and this is followed by a drop of sample oil placed at the centre of the drop of previous absorbed indicator.

If the change of colour is Red, it is acid
If blue/green, it is alkaline.
If yellow/green, it is neutral.

Foreign Particles Test

This can be done by either Spectrochemical analysis or Ferrographic analysis or Ferrographic analysis, each giving particle size less than 10 uM to 100 uM range depending on the tests applied.

The most powerful technique is Inductively coupled plasma atomic emission spectrometry (ICP OR PES), which uses a direct spray technique to determine the wear and contaminant elements present in the oil. This technique will in the main only detect the particles below 10 uM size.

In ferrographic test, the sample is thinned first with some solvents and allowed to pass slowly down a slide surrounded by powerful magnetic field.

Then it is examined by special microscope with red and green filters under lights. The shape of the particles is used to identify the source of the wear debris.

The advance ferrography method was added to the PFA (Progressive Fast Analysis) programme where all samples pass through the combination of two machines, a particle quantifier (PQ) and a rotary particle depositor (RPD). These test measures the induced magnetic moment of debris as deposited on a substrate or contained within a specific volume of liquid.

These machines provide accurate test by rotating the metal particles and then separating into three different sizes, Theses three bands of particles are examined by very powerful microscope to determine the type of materials and shape.

If more detailed examination is necessary, the debris may be subjected to a scanning electron microscope.

LUBRICATOR & QUILL

Lubricator

The lubricators are driven by a common drive from the engine it supply cylinder oil to the cylinder. They are synchronized with the engine to provide timed lubrication.

How to arrange to supply oil to cylinder (or) when they supply L.O to engine

Lube oil be fed to the piston at the time when the top two piston rings pass the lubricating holes in the cylinder during the pistons upstroke.

Timed lubrication

1) Lubricators of each cylinder are synchronised with engine to provide timed lubrication
2) Cylinder oil is fed; at the time when top two piston rings pass the oil feed points, in the cylinder during piston upstroke [4/S and 2/S Uniflow engines]
3) Loop scavenge Sulzer RND engine use accumulator system of timed lubrication
4) Accumulator provides constant oil pressure, which is greater than scavenge air pressure, with uniform supply at every period around TDC and BDC positions.
5) In this way, oil is delivered to quill, only when low pressure and temperature prevails on running surface of cylinder liner.
6) 8 supply points at top, and 1 point for scavenge and 1 point for exhaust ports at bottom

Timed lubrication has little merits, because

1) It requires *very rapid injection* of oil at correct time, with correct amount, and pressure
2) It is discharging through *very small bore;* with long pipes to various oil feed points
3) Having a *non-return valve* at the top of lubricator, hence it complicates the timed injection
4) The hot combustion gases tend to carbonise the oil, and block the orifices.

Lubricator Quill

Lubricator quills are arranged around the periphery of the cylinder liners and connect cylinder lubricators with oil feed points in the cylinder liners.

Requirement of lubricator *****

a. Must be capable of delivering regularly every stroke a quantity of oil against moderate pressure
b. Must have a wide range of adjustment
c. The quantity of discharged oil per strike should be clearly visible
d. Can be operated by hand

How do you do lubricator quill overhaul ?

01) Remove nut on lubricator quill (L.O connector)
02) Take out lubricator quill fitted directly to the cylinder without passing through the jacket cooling space.
03) Remove lubricator quill (L.O outlet side)
04) Take out spring and non return ball valve.
05) Clean all parts in diesel oil.
06) Check non return valve for occur.
07) Check spring tension.
08) Place the non return valve and spring into the lubricator quill then tighten out.
09) Fit the lubricator quill to the cylinder tighten the nut.
10) After fitting the lubricator quill, It is operated by hand at the same time check the cylinder liner wall for sufficient oil come out.

REQUIREMENTS OF CYLINDER LUB OIL *****

(01) It must ***reduce sliding friction*** between piston rings and cylinder liner to a ***minimum.***
(02) It must process ***adequate viscosity at high working temperature*** and still be sufficiently fluid to spread rapidly over the entire working surfaces to form a good adsorbed oil film.
(03) It must ***form an effective seal*** in conjunction with the piston rings, preventing gas blow by, burning away of the oil film and lack of compression.
(04) It must ***burn cleanly, leaving as little and as soft a deposit as possible.***
(05) It must ***effectively prevent the build up of deposits*** in the piston ring zones and exhaust ports.
(06) It must ***effectively neutralize*** *the corrosive effects on the mineral acids formed during combustion of the fuel.*

Effects of excess lubrication:

1). Fouling of ring grooves and resulting ring zone deposits.
2). Consequently, loss of gas sealing effect and blow by follows.
3). Fouling of scavenge space and scavenge fire follows.
4). Also affecting combustion process.
5). Leading to breakage of piston rings
6). Fouling of exhaust system and turbocharger.
7). Increase consumption.

Effects of reduce lubrication:

1). Promote wear of liner and rings
2). Overheating of local area resulting micro seizure due to lack of boundary lubrication.
3). Consequently major damage to piston and cylinder liner.

How to check correct amount of lubricator feeding ?

Checking by open scavenging drain (little coming out O.K) at sea.
In port: Check the liner is wet or not (thin layer wet O.K)
Oil has to not collect at the scavenge space.

BEARING

Classification

1) Main bearing
2) Top end bearing = Cross Head / Gudgeon Pin bearing
3) Bottom End Bearing / Crank pin bearing
4) Thrust Pad bearing
5) Pedestal bearing (generator alternator side insulated bearing)

1. MAIN BEARINGS

Function : Support crankshaft and keep it aligned.
To remove heat produced by friction

2. TOP END BEARINGS

Cross head Engines: Transmit load from cross head pin to connecting rod
Allows relative movement of con rod & cross head pin
Trunk Piston Engines: Transmit load from gudgeon pin to connecting rod
Allows relative movement of con rod & gudgeon pin

3. BOTTOM END / CRANKPIN BEARINGS

Function: Transmit load from con rod to crankshaft
Allows relative movement of con rod & journal

Bearing Operation: Depends on

- Operating temperature of bearing
- Working temperature of bearing
- Minimum oil film thickness
- Rate of oil flow
- Rate of heat production
- Power loss of bearing.

Bearing Loads: Combustion forces, Inertia forces & Centrifugal force of rotating masses

- ⇨ Varying resultant load from gas forces & inertia forces
- ⇨ Two stroke engine ➞ No load reversal
- ⇨ Four stroke engine ➞ Load reversals at the end of exhaust stroke hence, wear uniform & lubrication better.
- ⇨ Fluctuating gas force results fatigue failure in bearing

Bearing Material Properties

★ **Mechanical Strength**

- a Fatigue & compressive strength to carry load – depends upon thickness
- a 0.3 mm white metal can withstand 141 bar pressure and 0.08 mm white metal can withstand 211 bar pressure
- a Thin lining has poor conformability and too soft material tends to flatten under heavy loads
- a Too hard material withstands high loads, posses high frictional characteristics & may be brittle with poor fatigue characteristics.

★ **Soft & low melting point material**

- a Softness & modulus of elasticity of bearing alloy should be as low as possible but hard enough to withstand heaviest continuous loading or chock loading without plastic deformation

- a Soft metal flows locally without damaging the harder steel called conformability
- a Allows abrasive particles to embed to prevent damage to journal

★ **Corrosion resistance** – to withstand corrosive attack from lub oil

★ **Compatibility** between bearing & journal under boundary condition

- a Anti-weld & anti-score property between shaft & journal during start up & stop and by using turning gear.

★ **Antifriction & wear properties** –depends upon type of oxide film that material forms on reaction without lube additives.

Bearing Material

★ **White Metal** = Tin (Sn) +_ Antimony (Sb) + Copper (Cu)

- a Thin walled bearings, stiff cross head assembly ➞ 88% Sn + 8% Sb + 4% Cu
- a Thick walled bearing, flexible crosshead & Bottom end bearing ➞ 87% Sn + 9% Sb + 4% Cu
- a Tin forms soft matrix to accommodate misalignment
- a Antimony forms hard cubes to withstand load of journal. Tends to float and segregate during casting
- a Copper holds antimony in evenly dispersed pattern, solidifies first.

★ **Copper Lead & Lead Bronze** = Brass (Cu + Zn) & Bronze (Cu + Sn)

- a Can withstand 3 times higher load than white metal
- a Copper / Bronze matrix supplies the strength
- a Lead remains in free state, provides bearing properties and Steel strips provides backing
- a Overlay of 0.024 -0.04 mm thickness of lead –tin, lead –tin –copper.
- a Running in prevents acid attack against lead but poor embeddability & conformability

★ **Aluminum Tin** = Al Matrix + Si (minor) + Overlay7 (Pb+Sn) + Steel Backing

- a Soft Aluminum forms the matrix and provides embedability & conformability
- a Tin held in suspension provides bearing properties
- a Lead Tin Overlay of 0.02 mm for initial running in
- a 3 times load carrying capacity than white metal but requires hardened journal
- a Resistant to acid attack and fatigue strength same as Cu & Pb

Bearing – Lubricant – Shaft – Interaction

Bearing		Lubricant	Shaft	
Composition	Dimensional	Viscosity		
Strength	Surface Finish	Stability	Composition	Dimensional
Ductility	Bore Profile	Compatibility	Strength	Surface Finish
Fatigue Strength	Features	Adhesion	Hardness	Features
Conformability		Oiliness	Compatibility	
Compatibility		Additives	Corrosion Resistance	
Embeddability		Bulk Modulus		
Corrosion Resistance				

Bearing Material – Shaft Material – Lubricant

★ High local pressure at the point of contact

★ Localized welding at these points

★ Alloy formed at welds

★ Shear strength at welds.

★ Shear strength (alloy) > Shear strength (metal)

THIN SHELL BEARING

- **Wall thickness** to diameter ratio varies 0.05 mm for 40 mm shaft diameter and 0.02 mm for 400 mm shaft diameter.
- **Interference fit** or bearing crush
- **Fretting** – Interference fit resists relative movement, prevents fretting.
- **Locating Tags** - For correct axial location of shell but not intended to resist motion
  - Recessed below bearing joint face.
- **Free spread** - Bearing shell in snapped into bearing housing
  - Bearing can be held in place when inverted during assembling.

What is nip ?

The external circumference of a pair of bearing shell is slightly larger than the bore of housing. The difference is called nip.

Advantages of Thin Shell Bearings

- High load carrying capacity; approximately 5 time > conventional bearing
- Uniform wall thickness permits better metallurgical control of white metal casting process.
- High Bond Strength and ultrasonic method of bond testing between layers is accurate.
- Reduced thickness & absence of keying grooves results in higher fatigue strength
- Blistering on bearing surface due to H_2 emission form is less.

Oil Grooves on Bearing Shell

- Oil Grooves to avoid at pressure areas as oil tend to escape high to low pressure zones
- Circumferential grooves to compensate with increase length of the shell
- Longitudinal groove is not extended to ends to avoid excessive side leakage.

Main Bearing Groove

- Circumferential groove most effective and satisfactory
- Oil supply at all angle and wide variation of load angle.

Different between conventional and thin shell bearing ?

a) ***Conventional bearing***

(a1) It is made of forged steel and running face is lined with white metal.
(a2) Vertical clearance is adjusted by shims.
(a3) Not easy to replace and must be done remodeling.
(a4) Not easy to handle, transport and store.
(a5) Suitable oil grooves design is required.
(a6) Lower load carrying capacity.
(a7) More cost in manufacturing.

b) Thin shell bearing

(b1) It is made of tri-metal, they are steel shell, copper or lead alloy and thin layer of soft metal surface.
(b2) Easy replacement incase of bearing worn out. (Re-metalling method no longer required)
(b3) No need to adjust by shim (can not be adjusted by shims.)
(b4) Easy handling, transport and storage as spare.
(b5) Higher bearing load carrying capacity.
(b6) More economy in manufacturing.
(b7) No need to take lead reading.

Cause of thin shell bearing shifting ?

(01) Defective tag
(02) Insufficient nip clearance
(03) Suddenly applied extreme load.(pounding)
(04) Improper fitting
(05) Incorrect size of bearing use
(06) Due to over tightening bolts
(07) Frictional force from the back of the shell and keep.

Crosshead Bearing Construction Features.

★ Thin shell bearings are used and bearing on either end of crosshead pin.
★ No shim used with thin shell bearing
★ Oil grooves or gutter used on bottom half to distribute oil.
★ Grooves do not extend to end and grooves are small because of loaded half.
★ Grooves to be limited otherwise reduce bearing surface.
★ Lubricating oil is directly supplied to crosshead bearing
★ Bearing material usually Sn-Al with Pb-Sn overlay.

Crosshead Bearing Working Condition

⇨ **High sudden load** – Effect of combustion is directly on bearing
⇨ **High bearing pressure** – Bearing is placed high in engine. - Space limitations. – Assembly reciprocating.
⇨ **Diameter & length** – Diameter & length of bearing are low. – Bearing area limitations. –High specific loading
⇨ **Possibility of bearing distortion** – Bending moment & deflection are maximum at center. Pin bored at center (earlier model engines). Less stiffness & high stress concentration. – Bearing surface deflection. – Alignment difficulty.
⇨ **Lubrication** – Unsatisfactory or difficult oscillating moment. – Con rod swings over 25° -30°.
⇨ **Oil supply disturbed** – Difficult smooth & uninterrupted oil flow.
⇨ **2 stroke engine** – Unidirectional load.

Modification of Crosshead Bearings Over Last Few Decades:

⇨ Conjugate Deflection – Sulzer Engines (crosshead pin bored at center)
⇨ Crosshead mounted mechanical lub oil pump – MAN Engines (oil supplied when load is lowest & oil film is not broken at highest pressure)
⇨ Continuous full length bottoms half of crosshead bearing – MAN B & W, Sulzer Engines.
⇨ Eccentric bored bearing & machining shell – Fiat Engines
⇨ Large diameter stiff crosshead pins L/D ratio less (small con rod and crank throw ratio. Sliding velocity high & lub oil film improved)
⇨ Hardened cross head pin high degree of surface finish < 0.1μ
⇨ Thin shell bearing & improved material.

Bearing Housing Design Feature

☯ Bearing shells are in place by interference fit
☯ There is no relative movement of housing & shell
☯ Effective heat transfer between shell & housing is essential
☯ Cap holding bolts are to be closely pitched to prevent distortion
☯ Housing is robust to prevent excessive strains on shell.
☯ Housing is not too stiff to prevent localized load concentration on bearing.

★ *No fretting marks at the back of bearing shell and crush at bearing shell ends within limits*

★ *Medium & High speed engine's Con Rod bottom end bearing housing tendency to distort.*

BEARING CAPS

⇨ Load is always on down wards & construction is light
⇨ Load rotates but bearing cap is rigid
⇨ Bolts centers are kept close together.
⇨ Two halves of bearing housing is kept concentric by fitted bolts, stepped cap & serrate cap

BEARING BOLTS

⇨ Adequate tensile strength
⇨ High resilience, capacity to absorb maximum strain before yielding
⇨ Reducing diameter to bottom of thread over the length of the bolt reduces localized stress except at fitted.

INSPECTION OF BEARING & JOURNAL FOR DEFECTS

Bearing should be inspected at the overhaul / survey for the following defects

BEARING

1) **Abrasive damage:** Fine scratches caused by particles in the lub oil. Very common on HFO burning engines
2) **Erosion damage**: Removal of the overlay in strips caused when the oil supply pressure is low or rapid journal movements occur. More usual on medium speed engines.
3) **Fatigue damage:** The overlay becomes detached from the lining when the bearing load becomes too high. The bearing surface loads cracked paving.
4) **Corrosion:** Discoloration and roughening of the bearing surface indicate4s that the oil has become acidic.
5) **Wiping:** This is overlay removal by melting Wiping can be re-alignment of the bearing to journal, but if too much metal has been removed then clear4aqnces may be affected.

JOURNAL

1) **Cracks:** These will appear at the high stress points of the fillet radii and oil holes. These cracks may be removed by light grinding, but engine derating would be required if deep / numerous cracks are found.
2) **Scoring:** Similar problem to the abrasive bearing
3) **Overheating:** As the bearing is weaker than the shaft, the bearing should fail first. However if the engine is run on a failed bearing then shaft overheating will occur. This 'bluing' of the shaft increases the hardness of shaft and hence the shaft is less able to resist crack growth. Classification states a maximum hardness for crankshaft journal.

Bearing checking

1) Edge wear
2) Score & scratch (striation wear)
3) Overheating surface (blur/violent colour show heating cracks)
4) Cavitations & erosion (10% bearing surface)
5) Corrosion
6) Crack in galvanic layer
7) Pitting & fretting

Bearing Clearance: *Depends on* ---

- Desired operating temperature – extremely critical
- Oil flow $\propto$ (clearance)^3
- Working viscosity of lubricant
- Operating temperature
- Engine speed
- Oil film thickness
- Load carrying capacity
- Engine ambient temperature.

Bearing Clearance Methods:

It is important that regular checking of bearing clearance is carried out, as the clearance determines the effectiveness of lubrication.

- **Lead wire** > Traditional method, but requires that bearing are tightened just to obtain clearance. Accurate as long as load is not over squeezed. Lead is not to squeeze blow 1/3rd of original diameter.
  - Turn the crank shaft and set the crank at TDC position.
  - Remove locking arrangements, mark the nut position.
  - Slacken the nut and lower the bottom half with bolts.
  - Then three lengths of lead wires would be laid circumferentially in the bottom half at three places.
  - Place the bottom half into position and tighten the nut to its tightening torque.
  - Lower down the bottom half again.
  - Remove the lead wires and take the measurement.
  - It must have within the limit, if out of limit, the bearing shell must be replaced with new ones or readjust the clearance by adjusting shims.

- **Feeler gauge** > Quick method, but more difficult to be accurate when using the long feelers as measuring point may not be the minimum point.
  - Turn the crank shaft and set the crank at BDC.
  - Insert the feeler gauge between lower half and crank pin.
  - Take the measurement readings.

- **Plastigauge** > Relies on the width of a plastic strip after compression. More accurate than leads.

- **Bridge gauge** > Depends on bedplate condition and crankshaft rigidity

  Bridge gauge is an instrument for main bearing wears down measuring.
  - Remove the lube oil supply pipe.
  - Remove upper bearing half and fit the bridge gauge.
  - Then take the measurement by inserting feeler gauge.

- **Micrometer** > More accurate

Effect of excessive bearing clearance ?

- Low LO pressure
- Reduce load carrying capacity
- Pounding will case and bearing will damage.
- High impact load on crankshaft.

C /E's Procedure for Complete Inspection of a Crosshead Emphasizing Areas of Significant Interest (extract form B & W manual)

- The cross head bearings consists of steel shells with 1.0 to 1.5 μmm of white metal (WM) having a 25 μm lead based overlay for running in.
- Complete inspection may be carried out on a time basis i.e. after 8000 operating hours, for a 4 years survey of following inspection carried out without opening up.

1. Check without opening up

- Just after stopping feel over bearing, check that uniform oil jets appear form all the oil outlet grooves in the lower shell.
- Check clearance (on top) with feeler gauge and compare with records.'
- Visually inspect sides of bearing for signs of white metal squeezed / missing
- Dismantle & inspect if oil jets are oblique / twisted / reduced / missing / if white metal gives cause for concern or if clearances have increased.

2. Inspection & Overhaul

- Crosshead opened up, condition of white metal and journal surfaces noted and entered in engine room log. White metal should be checked for **wear / wiping / cracking / discoloration** due to corrosion / bonding defects.
- It is quite normal for the overlay to be disturbed at the most highly loaded areas.
- Overlay or WH squeezed into the oil wedges and oil grooves or small spots, which have loosened, can be removed with a scraper.
- If wiping is less than hand size scrape to **blue marking cracks** formation which will eventually cause WM to become loosened and dislodged may be due to lack of bonding strength or geometric irregularities causing local overloading.
- Areas of small local crack formation discovered at an early stage should be relieved by scraping.
- The back side of the shell should be inspected for even contact fretting or cavitation.
- Journals to be inspected for roughness and ovality; slight ovality is acceptable.
- Change journal if _
  - Loaded part is heavily worn
  - More than 1/3 of the contact area is scratched.
  - Roughness has caused a large area of the WM to be wiped
  - Manual polishing with hemp rope will not then be satisfactory.
- Coin test for roughness, No vibration heard or felt when lightly held coin is passed over the surface
- Surface roughness → New 0.05 μm, → Run in 0.1 μm, → Trouble possible 0.125 μm.
- Roughness will most likely be due to abrasive or corrosive (acid or SW) contamination of the lube oil.
- Note that 1% SW contamination of the lub oil can promote galvanic attack of the WM formation of **very hard black tin oxide** (Sno) which will roughen journal surfaces.

What point to be check after removing X head bearing ?

(01) Check bearing thoroughly.
(02) Check X head pin ovality.
(03) Check bearing clearance.
(04) Lubrication system and oil holes.
(05) Check Guide shoe wear down.

Types or Crosshead Bearing failure:

Various types of failure occur in cross head bearing lining. If it is found early, can be rectified and continue in service. Failure of the white metal in less- severe forms usually progress so that the bearing must be remetalled.

- ⇨ Cracking of white metal
- ⇨ Fatigue failure of white metal
- ⇨ Squeezing of white metal so that oil grooves are partially blocked; oil holes may be partially blocked or wholly blocked in extreme cases.
- ⇨ Failure of white metal when the bearing surface of the white metal becomes plastic or even melts.
- ⇨ Corrosion depends on the nature of the contamination of the lubricating oil.

Causes of Crosshead Bearing failure:

Bearing failures may result from any one or combination of the following causes.

- ⇨ Deterioration of surface finish or cross head pins.
- ⇨ Poor quality of white metal
- ⇨ Insufficient supply of lubricant
- ⇨ Impure lubricant or water contamination
- ⇨ Excessive firing pressure in cylinder

How to check the bearing ? (Bearing overhaul) ******

Before removal

- **a.** Check locking device and nuts tightness.
- **b.** Check for wiped out of loose white metal at bearing end.
- **c.** Check bearing clearance (roughly) by tongue gauge.

After removing

- **a.** Check pin or key or tag.
- **b.** Check holding down bearing surface.
- **c.** Check white metal bearing surface (crack and damage)
- **d.** If over 30 % of wear or crack in the contact area it should be renewed.
- **e.** Check oil grooves and passage holes.
- **f.** Check pin diameter & pin ovality

What points to be check after removing main bearing ?

- **(01)** Check bearing thoroughly (tag, oil grooves and holes, bearing surface)
- **(02)** Journal ovality-take measurement at least 3 spaces.
- **(03)** Checking bearing clearance-0.4 to 0.6 mm for 550mm shaft diameter.

What points to be checked after removing big end bearing ?

- **(01)** After cleaning, inspect the bearing thoroughly at crank pin ovility two halves of bearing together with oil holes and grooves.
- **(02)** Thoroughly, examined the bolts (no cracks, no extension and no twisting)
- **(03)** Check sign of movement of the joint point such as two halve of bearing joint and between top halve and connecting rod foot.
- **(04)** Bearing clearance.

What points do you check after removing upper half bearing ? ****

- **(1)** Check upper half bearing & bearing keep
- **(2)** Check the bearing wear down by using bridge gauge & feeler gauge ovality of journal pin
- **(3)** Check crack pin condition, oil holes
- **(4)** Check upper bearing clearance by lead wire method

(5) Visual check to edge of lower bearing half, bearing pocket

What points do you check after removing crank pin bearing ?

(1) Check pin ovality & oil holes
(2) Check two bearing halves with oil holes and grooves (tag, crack, wear,)
(3) Check the bolt (crack & stretching)
(4) Check the movement at the joining point such as two halves of bearing joint and between the top half and connecting rod foot

What points do you check on thin shell bearing during overhaul ?

1. Visual inspection of any wiping & squeezing
2. Check axial play
3. Check of local temperature after test run

For new thin shell

1. Fit into housing and check the contact area after thorough cleaning
2. After clean, check bearing running surface (any crack, grooves, tap)
3. After renew test run for 30 minute and again, after 5 hours operation, manual checking bearing temperature.

Check new bearing before fitted

- Bearing thickness, length, crack, surface smoothness, edge, oil hole, groove, tap
- Casing & keep surface
- Pin ovality,

How to decide that shell to be replaced ?

1. Shell with galvanic layer worn down over 30% of developed working surface to be replaced (X head 5%)
2. Running hour excess of 40, 000 to be replaced in any case (O/H or not)
3. Running hour excess of 30, 000 to be replaced when engine overhaul

How to check bearing wear down (Main bearing) without bearing removal ?

(1) Remove LO pipe connection from keep a bore has in the keep
(2) Hole also be provided in upper bearing half
(3) Clean holes & insert the depth gauge & take reading

The different of present reading & previous reading give lower bearing wear down

Bearing Problems & Diagnostics

Types of bearing defects ?

(01) Crack
(02) Fatigue failure of white metal
(03) Squeezing of white metal, so oil grooves are partially blocked.
(04) wiping
(05) Faulty casting and faulty machining.
(06) Tin oxide Corrosion
(07) Acid Corrosion
(08) Thermal Ratcheting
(09) Electrical Potential
(10) Fretting

(11) Cavitation Erosion

Wiping of Bearings Surface

- Wiping is a slight transient phenomenon & is undetected until the machinery is opened up for survey.
- *In serious cases, complete bearing failure occurs due to over heating of bearing metal which occur owing to -*

- Temporary lack of oil `
- Too small bearing clearance
- Fabricated cross girder of bedplate
- Very slow start up of engine
- Misalignment of pin and bearing
- Tin oxide corrosion

Nitride surfaces

- Surface to be machined at least by 0.025 mm to prevent bearing damage.
- Stainless steel shafts & white metal bearing surface – wiping, pick up & seizure
- **Failures** – Due to lack of compatibility and the problem is worst at high specific load.
- **Ni or Cr Plating**: on journals / pins must be voided which results in scuffing seizure.

Fretting

- In dynamic loaded bearings / pivoted pad bearing i.e. thrust pads of thrust bearing
- Fretting occurs on the back of support surface where the interference fit / nip is insufficient for dynamic forces involved.
- Caused by the housing, which is insufficiently rigid for the load cycle involved.

Fatigue

- Bearings carrying high dynamic loads are liable to fatigue damage
- Caused by a concentration of load due to mechanical imperfection i.e. poor geometric form, misalignment and distortion.
- White metal bearings are particularly prone to fatigue since any high loading not only increases the stress in the lining, but the associated temperature rise reduces the strength.

Causes of fatigue cracking is due to poor bonding of white metal to its steel shell.

Tin Oxide Corrosion

- Tin oxide is extremely hard & brittle and corrosion takes place at tin phase of white metal
- This breaks off rapidly, causing wear of the surfaces & breakdown of oil film
- **Appearance** – Grey at initial stage, becomes darker as its thickness increases & particle become detached.
- With high loads when the oxide layer becomes thick, the bearing temperature may rise sufficiently to melt the underlying metal & failure occurs by wiping.
- **Cause** - Water mixes with LO promoting electro chemical reaction.
- **Prevention** – Regular & continuous removal of water from lubricating oil prevent tin oxide formation.

Acid Corrosion

- Takes place in high temperature condition
- Bearing alloy is attacked by acid (condensation of SO2) form high 'S' content fuel.
- Steel working parts corrode more than bearing alloy
- **Solution** – Add rust & corrosion inhibitor in lub oil and select proper material.

Thermal Ratcheting

- **Caused** by alternate cooling & heating of bearing

- ⇨ **Results** in bearing deformation
- ⇨ **Indication** of high bearing temperature
- ⇨ **Place** mainly in thrust pad bearing surface

Electrical Potential

- ⇨ This type of damage occurs frequently in electrical machinery due to stray currents.
- ⇨ The damage consists of uniformly distributed pitting, the pits being generally hemispherical with the intensity increasing to a maximum in the zone of thinnest oil film.
- ⇨ **Caused** by incorrect earthlings system which cause spark erosion damage.
- ⇨ **Prevention** – Insulate the non-drying end bearing (pedestal bearing) of electrical machines and sometimes in both bearings.

Cavitation Erosion

- ⇨ Severe damage to complete bearing area.
- ⇨ Cavities are usually around at low pressure areas i.e. oil groove or oil holes.
- ⇨ Caused by an implosion of gas or air bubbles released from a lubricating oil film under particular conditions
- ⇨ The pressure set up locally during theses implosions are very high , possibly 220 bar & may cause a pitting / cavitation
- ⇨ **Prevention** – May be reduced by viscous oil because of damping effect high viscous oil & viscosity must be in limit.

Cause of white metal squeezing is when bearing metal is pressed out into the oil groove due to load on bearing exceed its compressive strength.

Cause of faulty casting and machining is due to premature failure even under normal running conditions.

Causes of bearing overheat

- ⇨ Improper viscosity of oil (lower)
- ⇨ Insufficient lubrication
- ⇨ Improper oil clearance
- ⇨ Foreign matters in oil
- ⇨ Misalignment of shaft and bearing
- ⇨ Scored journal
- ⇨ Poorly fitted bearing

Big end/crank pin bearing bolts failure

1. Over stressed on bolts (due to piston seizure, over tightening, propeller strike some obstruction)
2. Too long in service (renew after 10 years)
3. Wear of bolts & enlarge of holes can cause the easing of nuts.
4. Too much clearance of bearings, shock resulting fatigue in bolts

What do you do if intermediate bearing or tunnel bearing or plumber block bearing temperature is increase ?

Overheating of plumber block bearing can be reduce by following ways

- ✔ By applying maximum lubrication
- ✔ By applying maximum cooling
- ✔ By reducing to suitable engine speed.
- ✔ By applying the air

- ☑ By removing the cooling outlet pipe
- ☑ By filling the L.O into the sump at the same time open the drain valve and drain out the hot oil
- ☑ By reducing the engine speed to the suitable speed.

How to check plumber block at sea ?

- ☑ Check L.O level and L.O temperature
- ☑ Cooling water outlet temperature
- ☑ Noise and vibration
- ☑ Overheating of casing by hand touch feeling

Main bearing removing procedure.

Measure bearing clearance.
Turn crank shaft to efficient position.
Remove lube oil pipe, locking arrangement and nuts.
Took out bearing keep with thrust nut by means of wire sling and chain block or special tool. Took out upper bearing shell.
Took out lower bearing shell.

1. By fitting lower bearing taking out tool fitted at oil hole at crankshaft or adjacent crank web and turn the crank shaft (the direction is according to the maker instruction, usually opposite to the ahead running direction.)

2. By use of hydraulic jack to lift the crankshaft just clear, about 0.1 to 0.3mm and turn the bearing shell without rotating the crank shaft.

Eye bolt fitted to the back of the shell and lift it out of the engine.

Big end bearing removing and fitting procedure.

1) Measure bearing clearance.
2) Turn TDC position.
3) Remove locking arrangement and slackened the nuts. The bottom half lower a few and took out bearing clearance adjusting shim, each set being tied separately and note taken of the side to which each set belongs.
4) Chain blocks connected to eye bolts, screw into each bolt. After removing two nuts, bottom half lowered into the sump. If necessary it can be taken out from crankcase.
5) Putting hanging bar in position, connect chain blocks to crankcase door frame and eye bolts which is screwed into each side of the top half. Then turn the crankshaft to the position where the top half can be taken out.
6) Inspection on crank pin, bearings, oil holes, grooves, bolts cracks, sign of movement and elongation.

BOILER

What is the meaning of boiler ?

It is a pressure vessel in which the water is heated to evaporate and generate the steam and the unit is so arranged that the generated steam accumulated in it. The two main types are water tube and fire tube.

1. What is the boiler mounting ?

It is directly fitted to the boiler shell. They are **1**. Safety valve **2**. Main steam stop valve **3.** Air vent cock **4.** Two gauge glass level indicators **5**. Feed check valve **6**. Scum blow down valve **7**. Bottom blow down valve **8**. Salinity cock or test cock **9.** Man hole doors.

2. Where are air vent cock located and its purpose ?

The air vent cock is fitted at the top of the steam space of the boiler.

Its purpose are-

1. To release air from the boiler either filling the boiler water or raising the steam.
2. To allow air to enter in the event of boiler cooling down or blowing down .(to prevent vacuum effect)

3. Boiler safety devices ?

1) Safety valve
2) Low / high water level alarm
3) Too low water level alarm and shut down
4) Water level indicators
5) Pressure gauge
6) Low fuel oil pressure alarm
7) Low / high fuel oil temperature alarm
8) Flame failure alarm
9) Smoke density alarm
10) Easy gear arrangement
11) Air vent
12) Force draught fan stop alarm
13) Low / high steam pressure alarm

4. Why need to blow down the gauge glass ?

Gauge glass blow down is made to know the boiler and gauge glass connection is clear or not and to give the exact water level in the boiler.

5. Boiler gauge glass blow down procedure ?

1) Shut steam and water cocks than open the drain cock.
2) After draining water from the sight glass, there is nothing come out, both steam and water cocks are good in order.
3) Open the steam cock side, blow out the steam.
4) Close the steam cock side, the steam connection is clear.
5) Open the water cock side, blow out the water.
6) Close the water cock side, the water connection is clear.
7) Close the drain cock.
8) Open the water cock, water should then gradually come rise up to the top of the gauge glass.

9) Open the steam cock, the water in the glass should fall to the level of the water in the boiler.
 # Working position – all cocks handle are in downward position.

6. Why need to blow down the boiler water ?

Boiler blow down is made to reduce the density of salt and to remove the dissolved and suspended solids, also the floating solid impurities in the boiler system.

If there are not removed from the boiler water system, foaming, priming, corrosion will occur in the boiler steam space and feed water system.

7. Why do scum blow down and bottom blow down ?

Scum blow down (surface blow down)

To remove accumulated, suspended and floating solids, impurities and also remove dissolved solid concentration, they hinder the formation of steam.

Bottom blow down

To remove suspended solids and residual sludge that have settled at the bottom.

If these contaminants are not removed regularly they will build up until they hinder the circulation patterns.

8. Purpose of boiler water test ?

- To ensure that proper chemical treatment are maintained at all time.
- To detect the present of contaminants in the water that may be injurious to boiler and system.

9. Enumerate the boiler water test

1) Alkalinity test
  - **a.** Phenolphthalein (p) alkalinity test
  - **b.** Total (T) alkalinity test (2 x P)

2) Chloride test
3) Condensate PH test
4) Amerzine test (Hydrazine test)
5) Excess phosphate test
6) Conductivity test (Total dissolve solids test)
7) Hardness test

10. Purpose of Boiler water test ?

1) Alkalinity test

This is to ensure that the boiler water prevent corrosion by neutralisation of acidic gases

(a) Phenolphthalein (p) alkalinity

- ⇨ This test is carried out to prevent acidic corrosion
- ⇨ To test for presence of all of the hydroxide, one half of the carbonate and one third of phosphate present in a water sample. ***

(b) Total (T) alkalinity test

- ⇨ To determine the amount all of hydroxide, all of the carbonate, and two thirds of the phosphates

Note: *Hydroxides and carbonates can co-exist together in a solution but hydroxides and bi-carbonates cannot.*

2) Chloride test

- ⇨ To know the amount of salt in boiler water. ***
- ⇨ To minimize chloride level and to adjust the blow down.

3) Condensate PH test

- ⇨ To control condensate PH value within a limit. ****
- ⇨ To minimize corrosion in steam and condensate system.

4) Amerzine test (Hydrazine test)

- ⇨ To test for dissolved Oxygen content ****
- ⇨ To know reserve hydrazine (N_2H_4) ppm and to prevent corrosion and aeration.
- ⇨ To minimize oxygen pitting and corrosion in boiler, steam and condensate system.

5) Phosphate test

- ⇨ To control the scale formation due to hardness (presence of Phosphate in sample means no hardness salts) ***
- ⇨ A reserve of phosphate should be maintained in the boiler water ready to neutralize any hardness salts which may enter.

6) Conductivity test

- ⇨ Measure of the total amount of dissolved solids (T.D.S) including the treatment chemicals. (Excessive density leads to priming and or deposits) **
- ⇨ To remove dissolved and suspended solid by blowing down.

7) Hardness test

- ⇨ To check for salt causing “hardness”

Note

Hardness test of boiler water are not necessary when the phosphate is above the lower limit of the control range.

11. Purpose of boiler water treatment

1) To prevent the scale formation in the boiler and feed system
2) To prevent corrosion in boiler and feed system.
3) To control the sludge formation and prevention of carry over with the steam.
4) To maintain the boiler water in alkaline condition and free from dissolved gases.
5) To prevent of entry into the boiler of foreign matter such as oil, waste, mill scale, FeO, Cu , Sand etc.

12. What is foaming in boiler and how to prevent it ?

It is the formation of thick layer of steam bubbles on the top of the water surface inside the boiler due to:

- High concentration of impurities.
- By the animal or vegetable fats in feed water carry over from the oil heaters.
- Increase in level of dissolved & suspended solid TDS level.
- Increase in water level.

To prevent foaming, surface or scum blow down should done frequently to expel any floating impurities for the boiler and no lube oil should be allowed to enter the boiler.

13. What is boiler priming and how to prevent it ? ****

It is condition in which large amount of water are carried along with the steam into the steam line.

It is caused by **1.** Excessive foaming **2.** Improper amount of steam space **3**. By a sudden rush of steam such as is produced when steam stop valve is suddenly opened.

To prevent priming, never keep the water level too high.

Open steam stop valve slowly.

What action do you made take in case of foaming and priming ?

1. Scum blow down
2. Reduce boiler fire rate
3. Check whether boiler chemical added are in excess
4. Detect the source of contamination
5. In case of bad priming the boiler may have to be taken out of service, shut down.

For contamination due to oil have to be chemically cleaned.

14. Boiler blow down procedure (cool down)

1) Change the fuel oil burning system from HO to DO and then shut down the burning system.
2) Stop feed p/p close feed check valve.
3) Drain down the boiler after allowing it to cool down.
4) If no sufficient time to do this, lower the boiler pressure to 3 to 4 bar.
5) Shut the main steam stop valve.
6) Open the ship side valve then open the blow down valve.
7) Banging noise will appear when boiler is empty.
8) Close the boiler blow down valve and ship side valve.
9) Then release the steam pressure through safety v/v by means of easing gear.
10) When pressure is off, open the air vent and the boiler to cool down.

Opening up and Inspection Procedure

Follow as procedure above, After making sure no vacuum in it, first---

1. To remove top man hole door, slacken the dog holding nuts but do not remove them until first broken the joint
2. Remove nuts and dogs and take out the door.
3. The bottom door can be removed after warning personnel to keep clear of the top door.
4. Make ventilation before entering. Do not allow naked light near the boiler.
5. Preliminary internal inspection carried out before cleaning, to check scale deposits and any special points.
6. Plug orifice to blow down valve to prevent choke, place guards over the manholes landings to prevent damage.
7. Carried out cleaning and internal works.

When all works completed, a ***full internal examination*** must be carried out

- Cleanliness, all openings are clear, water level gauge connection clears from deposits,
- All internal pipes and fittings have been replaced correctly and securely attached,
- Remove plug from the blow down valve orifice,
- The face of manhole doors and landings inspect to clean and undamaged).
- Replace manhole doors by using new joints.
- Operate all boiler mountings. Open air vent cock and fill the boiler with water to sufficient level.

15. Describe the boiler fresh up procedure from cool condition ?

The boiler is carried out firing from cold condition to normal working pressure condition to avoid thermal stress.

1) Check the boiler blow down valve in close position.
2) Shut the main steam stop v/v.
3) Open the air vent cocks.
4) Open the feed check valve and pumping up to ¼ of gauge glass level.
5) Start the force draft fan with dampers, open correctly to purge the furnace and combustion space of any foul gas.
6) Light the burner after closing the recirculating valve.
7) Normally allow the fire to burn for 5-minutes and stop for 30 mins. This step continues until steam come out.
8) When steam coming out from the air vent close the air vent.
9) Rise up the working pressure step by step slowly. (Allow the fire to burn for 30 mins and stop the fire for 10 min.)
10) When the steam pressure reached Is working pressure drain the steam line. (to avoid water hammer)
11) Main steam stop valve open slowly (crack opening)

16. How do take action if gauge glass showing low water level ?

If water level has not yet dropped completely out the sight glass, water may be put into the boiler.

If water drops completely out of sight glass, check another sight glass, if both disappear water; do not add water until the boiler is cool enough to prevent any possible damage due to rapid cooling of over heated plate.

1. The fire must be immediately stopped.
2. The main steam stop valve must be closed.
3. Blow down and cool down the boiler.
4. Check leakage, drum outside, Located the cause of trouble and make necessary repair.
5. Enter the boiler after it has cooled and examined any possible damage.
6. After repair, water fill up slowly and restore to normal operation.
7. If no damage occurred, inject the water slowly into the boiler and restore it to operation.

Possible causes:

- One gauge glass defective
- Boiler tube crack and leaking
- Feed regulator jammed
- Fail feed pump (Air in feed water line or pump)
- Level controller malfunction
- Steam consumption is too much

16. What is caustic embrittlement? How to prevent it ?

It is inter crystalline fracture. It is cause by high concentration of caustic soda and the material under stress. The stress corrosion cracks follow the grain or crystal boundaries of the material and failure.

Sodium sulphate or sodium nitrate is used for the prevention of caustic embrittlement.

It can be found in highly stress area in boiler. Such as tube and tube plate connection, riveted head, seam and boiler mountings.

Erosion

It is a mechanical attack on the metal surface which may be due to a disturbance in the flow of the fluid over the metal surfaces, resulting in a loss of metal. Suspended abrasive matters in the fluid can increase the rate of metal losses.

Corrosion

It is the deterioration of metals due to oxidation. The present of water in an acidic condition provides the electrolyte required for corrosion action.

Two forms of corrosion

Direct chemical attack

It occurs when metal at high temperature comes into contact with air or other gases, resulting in oxidation or sulphidation of the metal.

Electro-chemical action.

Galvanic action, this being set up when two dissimilar metals are placed in an electrolyte. The noble of the two metals form a cathode to the base metal which, forming the anode, is wasted away.

Caustic embrittlement.

Caustic embattlement is a form of inter crystalline cracking, which results from a solution of sodium hydroxide or caustic soda, becoming more and more concentrated at the bottom of a crack or fissure (narrow opening) which may be the result of fatigue, in the boiler plate or furnace.

The plate must be stressed intention (]yi:]yi: xexe oua7muon), so that wastage take place at the bottom of crack, the plate weakens, the crack extends to expose new metal to the caustic action and thus it proceed.

Caustic embattlement will only occur when there is a high caustic alkalinity that is when the ratio of NaOH to the alkalinity is high. To keep this ratio at the safe level the sodium sulfate to sodium hydroxide should be maintained above 2:5. The sodium sulfate comes out of solution in high sodium hydroxide concentration and by doing forms a protective layer on the surface of the plate.

Also keep the lowest T.D.S level. (Total dissolved suspended & solid)

pH value

Logarithm of reciprocal of hydrogen iron concentration.

17. What do you do for preventing of oxygen ?

The oxygen-scavenging chemical which is used for deaeration the water are usually sodium sulphate or hydrazine.

$2Na_2So_3 + O_2 = 2Na_2So_4$

$N_2H_4 + O_2 = 2H_2O + N_2$

Excessive dosage of hydrazine could lead to steam and condensate line corrosion due to ammonia being produced as the excess hydrazine decomposed.

In high pr boiler, by using the sodium sulphite, the sulphite can break down to give hydrogen sulphide which can attack steel brass and copper.

18. If chloride is found too much in your boiler water what will you do ?

- ☞ Blow down frequently
- ☞ Reduce the boiler load to minimum.
- ☞ If highly contaminant shut down completely and wash out.
- ☞ Trace and find out the fault and remedies.

19. What do you understand composite, alternative, and economizer boiler ?

Composite boiler

If exhaust gas and oil fired can be used the same time, it is termed the composite boiler.

In this type a separate nest of tube for exhaust gas is provided, situated above the return tubes from the fire furnace. Uptake from the tube nest are separated.

Alternative boiler

If the exhaust gas and the oil fire are arranged to be used only at a time, the exhaust gas boiler term as the alternative boiler.

This unit can be oil fire heated by the exhaust gases alternatively.

It required only one uptake.

Economizer

In this system a separate exhaust gas economizer is connected to an oil fired auxiliary boiler or an accumulator by means of piping and a set of circulation pump. Exhaust gas is used as heating medium and it has no steam space.

20. What is meant of accumulation pressure ?

Accumulation pressure is the rise in boiler pressure which take place when the spring loaded safety valve lift due to the increase loading caused by further compression of the spring.

21. Purpose of accumulation pressure test ?

To detect the safety valve is suitable for this boiler or not. *To limit the rise in boiler pressure under full fire condition.*

22. Procedure of accumulation pressure test ?

This test is carried out a new boiler or new safety valve.

1) Shut off feed water
2) Closed main steam stop valve.
3) Arrange the boiler fire rate to a maximum.
4) Safety valve will be lift during the test.
5) The test is carried out as long as the water permits in the boiler. During of the test is 15 mins for a tank boiler and 7 mins for water tube boiler
6) Accumulation pressure should not exceed 10% of working pressure.

23. Safety valve setting under steam pressure ?

Setting of safety valves:

1) Take standard pressure gauge (approved by surveyor) for accuracy.
2) Fill up water up to ¼ of gauge glass level, and shut main steam stop valve, feed check valve.
3) Without compression rings, hoods and easing gears, reassembled the safety valves with spring compression less than previous setting.
4) Raise the boiler pressure to desired blow off pressure.
5) Screw-down spring compression nuts of any lifting valves, until all are quite.
6) Arrange to have the desired steam pressure
7) Adjust each valve in turn:
   a. Slacken compression nut until the valve lifts.
   b. Screw-down compression nut sufficiently enough, so that when the valve spindle is lightly tapped, valve return to its seat and remain seated.

c. Measure gap between compression nut and spring casing.
d. Make a compression ring equal to this gap, and insert under compression nut.
e. Gag the spindle of this safety valve, to prevent opening, while remaining valve is being set.

8) Remaining valve is again set and insert compression ring.
9) Remove gag and retest both valve to lift and close together.
10) Cap, cotter and easing gear to be refitted
11) Caps and cotter pins padlocked to prevent accidentally altering the setting.
12) When the surveyor satisfied the setting pressure, easing gear should be tested.
13) All safety valves set to lift at not greater than 3% above approved working pressure (design pressure).

24. How do you take action if one of the passages of gauge glass is chocked ?

Steam and water cocks and passages in the gauge can be cleared while the boiler is still steaming.

To do this, shut the steam and water cocks and open the drain cock. Remove the check plug opposite the obstruction. Insert the cleaning plug. Screw in the plug with small hole about 5 mm diameter, drilled through it in place of the cleaning plug. Insert into this hole a rod of such a size that held by a gloved hand, it can be easily moved without being stack.

Then open the chocked and push the rod through to clear the blockage. When clear, open drain to prevent a build up of pressure and only a small amount of steam will blow past the rod, the glove protecting the operator from injury.

Then close the cock and replace the normal cleaning plug. The gauge glass can be tested now and if satisfactory return to service.

*Do not carry out this operation on a plate type glass on a high pressure boiler.

25. Causes of furnace blow back ?

⇨ Insufficient purging time,
⇨ Accumulation of oil in furnace from the leaky burners,
⇨ Boiler tubes and uptake have full of soots.
⇨ Air registers control not operating for the high flame mode.
⇨ Too little air
⇨ Insufficient oil temperature

26. How to keep boiler not in service ?

For fire tube boiler out of service for short period, the boiler must be completely filled with alkaline water.

The boiler must be topped up periodically and any air in the system must be got rid off.

Regularly test the boiler water and keep the alkalinity and phenolphthalein in the range of recommended value.

<u>If the boiler is to be taken out of service for long periods.</u>

It should be drained completely and open up.

Dried out by means of heater units.

Then the trays of quick line should be place internally in suitable positions.

Blanks should be fitted to the pipe connections in the event of steam being maintained in other boiler and blow down line.

The quick line should be renewed at least once every two months.

27. The purposes of boiler water treatment ?

- To prevent scale formation (Trisodium phosphates is used)
- To remove trace of oxygen (sodium sulphide or hydrazine is used)
- To give alkalinity and minimize corrosion.(sodium hydroxide or sodium carbonate is used)
- To reduce risk of caustic cracking (sodium sulphate or sodium nitrate is used.

28. Difference between safety valve and relief valve ?

Safety valve

1) Directly open the design lift at set pressure.
2) Can open manually by easing gear.
3) Setting pressure is just above the working and not more than 3% above the approved working pressure.

Relief valve

1) Setting pressure is 10% above working pressure .
2) Opening is proportion to the increase in pressure.
3) Can not be open manually.

29. Marking on safety valve ?

- Manufacturer's name
- Serial number
- Inlet diameter
- Operating pressure
- Discharge capacity
- Safe working pressure
- Blow off pressure

30. Types of boiler by pressure ?

Low pressure boiler - up to 10Kg / Cm^2
Medium pressure boiler - 10-25 Kg /Cm^2
High pressure boiler - Over 25 Kg / Cm^2

31. What is water hummer / how will you prevent it ?

The impact of moving water in steam line when the steam is allowed to enter a line with condensed water. The steam will condenses and partial vacuum occurred and move back the water the along the pipe with very high velocity, and the water will strike at the vent or valves.

To prevent the water hummer –

a) Install steam trap in the line
b) Open the drain first before allowing the steam into the line.
c) Crack open of steam valve at first.

32. How to make boiler water test on your ship ?

The boiler test is carried out as follows.

Firstly take the boiler water sample from the salinometer cock or test cock and cool down.

The test is carried out by the using maker's supply test kit, chemicals, instruments and instructions.

33. How do you take boiler water sample ?

⇨ Slowly open the salinometer cock until clean hot water coming out.
⇨ Then collect the boiler sample with copper jar.

34. How to know scum valve open or not ?

It can be check by opening of ship side blow down valve. Banging noise will appear, scum blow down valve is in open position.

It can also detect, over heating of scum blow down pipe.

35. Where is manhole doors fitted ?

They are fitted at one at steam side and other one for steam side.

36. Effect of foaming and priming ?

a) can occur water hummer
b) can cause contamination and scaling.
c) Can cause fluctuation of working water level.

37. What is blowback ?

It occurs when lighting up with explosive gas and oil droplet (Oil residue) inside the furnace without pre-purging sufficiently.

The ignition results in a large flue gas inside the furnace and these gases blow out with increase high pressure through the furnace opening.

38. Procedure for hydraulic pressure test ?

Hydraulic pressure test is 1.25 times working pressure, (10 minutes maintain) Close all opening.

1) Open air vent cock.
2) Fill up boiler water fully
3) Close the air vent cock
4) Place hydraulic jack to feed water line.
5) Fit standard pressure gauge.
6) Applied hydraulic pressure 1.25 times of working pressure and maintain 10minutes.

39. What is liquid coagulant ?

It is more molecular wt colorless solution, such sodium aluminates, starch, terming, and resin.

Once being dose into the boiler water floating solid particles and suspended solid are settled to the bottom of the boiler and easily remove by blowing down.

40. How to renew the boiler gauge glass ?

⇨ Shut steam and water cocks and open drain cock.
⇨ Check any leakage from the respective cock.
⇨ Slacken the gland nuts.
⇨ Open the cap and remove gauge glass.
⇨ Fit new gauge glass, correct size and length into its space.
⇨ Give the expansion allowance 1/8 in vertical clearance.
⇨ Use new packing.
⇨ Close the cap.
⇨ After fitting, warm the glass by steam.
⇨ Tighten the gland nut.
⇨ Then steam and water pressure should be tested whether they are fair and clear.
⇨ Close the drain and open the water and steam side cocks.
⇨ Check the leakage; all are satisfactory put back into operation.

41. Boiler maintenance:

⇨ Clean the rotating cup.
⇨ Check and adjust the belt tension between motor and rotating shaft.
⇨ Clear the pilot burner nozzle and fitter.

- ⇨ Clean carbon deposit on electrodes (igniter) and adjust the gap.
- ⇨ Check the fuel valve and air register linkages and joints.
- ⇨ Check and clean the flame eye cover glass.
- ⇨ Check and clean inspection peep hole glass cover.
- ⇨ Adjust the fuel air ratio.
- ⇨ Clean fuel oil fitter.
- ⇨ Check the fuel oil pressure.

42. When boiler safety valve setting made ?

- ☞ Every boiler survey.
- ☞ After safety valve overhaul.

43. Why ship side blow down valve is open first and close last ?

- ☞ To prevent pressure build up in blow down line.
- ☞ In pipe burst, it may injurious to watch keeper.

44. If no test and treatments is done to boiler, the following may rise.

(01) Reduction in boiler efficiency due to poor heat transfer
(02) Reduction in tensile strength
(03) Reduction in factor of safety
(04) Overheating of metal resulting distortion and eventual failure
(05) Increase in fuel consumption
(06) Excess concentration of NaOH (caustic soda) may cause caustic embrittlement on boiler metal and tend to failure of boiler metal
(07) Corrosion
(08) Scale formation
(09) Foaming, Priming, carried over (due to increase T.D.S level, foaming is present and tend to carried over and priming)

45. Control of Evaporation (How to control / reduce excess EGE pressure)

01) By regulating the amount of gas flowing over the extended surface, i.e. by damper regulation.
02) By dividing the unit into sections so that each section is controlled by an inlet valve.
03) By passing steam through an automatic pressure controlled surplus valve to a dump condenser.
04) By a system designed for a higher pressure than that it is to operate.

Soot Blow

Purpose → To remove soot, to prevent EGE fire
→ To get steam generating efficiency good
→ To increase heat transfer efficiency

Time → Day time at sea 2 -3 times/day
Procedure → Inform to bridge
→ Check wind direction, good it transverse direction
→ Raise boiler pressure
→ Open drain cock until drain clear
→ Open soot blower valve
→ Open steam valve & carried out by turning wheel 20 -30 sec
→ Then close steam valve, soot blower valve
→ Open drain valve

Boiler safety valve closed examination and attention during overhauling

Checked its valve and valve seat for wear, cavity corrosion and any fault. They should be grounded properly but maker's limit must be maintained such as width of seating, clearance between valve lip and seat.

Valve chest must be cleaned condition and drain line clear.

The spring should be hammer tested for any fracture and check for corrosion. Free length is limited to 0.5 % of original free length.

The spindle should be hammer tested for any crack and its straightness.

The guide plates and bushes are checked for uneven wear and have sufficient clearance to allow free movement of spindle.

The compression nut and cover bush's threads are carefully checked it for any sign of wear and tear.

The easing gear should be checked in good order including bearings, cable pulley, and connecting links.

Connecting pin should be a free fit in the lid (t z:) and pin should not bent or pinhole gone out of shape.

All safety valves are to be set to operate under steam a little above working pressure not greater than 3% above the approve working pressure of the boiler.

Why safety valve is fitted in two numbers ?

To make sure that the positive discharging of higher steam pressure from boiler efficiency.

Why fitted in one valve chest ?

To reduce stress by hole on pressure vessel (boiler)

To minimize the numbers of cutting hole on boiler to save it's strength.

COMPRESSOR AND AIR BOTTLE

1. What is emergency air compressor ?

It is a small compressor independently driven by diesel engine or hand operated.
It must be fitted to press up the emergency air bottle and to start auxiliary engine of a dead ship. It has no connection between the main air bottle.

2. Air compressor safety devices ? ******

- Bursting discs are fitted on the cooler shells (At water side).
- Relief valves are fitted to discharge side for every stages.
- Moisture drain valve (unloader) are fitted at each cooler side
- Cooling water failure alarm.
- Low L. O pressure alarm.
- Delivery air high temperature alarm on after cooler outlet (Max 93°C)

LP discharge pressure 4 bars : HP discharge pressure 30 bars.
Intercooler inlet air 130℃ : Intercooler outlet air 35 ℃
After cooler inlet air 130℃ : After cooler outlet air 35℃
Intercooler is single pass type : After cooler, double pass U-tube type

3. Purpose of unloder valve (moisture drain valve) ?

At starting this valve must be opened, this reduced the starting torque for the machine and clear out any accumulated moisture and oil in the system.

4. What would be affect of suction valves of an air compressor having too much lift ?

The valve will be late in closing and this would reduce the volumetric efficiency of the machine .The valve too much lift reach at the end of their travel will grater force and therefore are more liable to break.

5. Affects of reduced volumetric efficiency of air compressor ?

- Grater bumping clearance.
- Sluggish opening and closing of suction and delivery valves.
- Insufficient cooling water that effect of high air temperature.
- Dirty or partially chocked suction air fitter.

6. Different between relief valve and bursting disc ?

Pressure relief valve

- Excess pressure is released by opening the valve.
- It opens at 10% over working pressure.
- Valve lift is proportional to excess pressure build up.
- Valve setting pressure can be altered by spring tension.

Bursting disc

- Pressure is released by bursting the disc.
- It permanently damaged.
- It burst at setting pressure.
- Setting pressure cannot be altered in place.

Fusible plug

- When the temperature high (above 105 °C) Pressure is released by melting (fusing) the metal.
- It cannot be used next time. (permanently damage)
- Release all content or pressure to empty.

7. Why multistage compressors are mostly used than single stage compressor ?

- More stages are needed to increase the required final pressure.
- Easier to control the air temperature.
- Reducing in air compressor size.
- Lubrication problem does not exit.
- Reduced the thermal stress.
- Lower work done to compressing air.
- Improve compressor efficiency

8. Advantages of inter cooling of air compressor ?

To avoid excessive temperature rise associated with higher compression ratios, and to approach isothermal compression.

- Saving in power.
- Volumetric efficiency is increased.
- Reduced the volume of air delivered and also reduced the compressor size.
- It can reduce the air temperature.
- Due to less temperature suction & delivery valves remain cleaner without being fouled with carbonized oil.
- It can avoid a danger of an explosion takes place in compressor cylinder.
- It allows good lubrication of the compressor piston.
- Moisture separation is easier through inter cooler drains.
- It also enables to deal with a greater wt of air for the same energy expended.

Why intercooler will fitted in Main air compressor?

1. Reduced air temperature, volume and increased air density for next stage
2. So increased Volumetric efficiency and compressor efficiency.
3. Due to reduced temperature give better lubrication for cylinder and piston rings
4. Drain are fitted from which water and excessive oil can be drained out, to prevent air bottle corrosion and starting air explosion and fouling of inter coolers and pipe.
5. Save the work done.

Advantages of after cooler purpose

- To reduce final discharge air temperature thus air bottle seize can be reduce.
- To reduce air volume after it has been compressed to the final pressure.
- So greater amount of air could be stored in air bottle.
- Increase volumetric efficiency

9. How to start the air compressor manually ?

- Change the switch to manual position on the switch board.
- Check the L.O sump level and condition.
- Open the moisture drain valve.
- Open the compressor discharge valve & charging valve of air bottle.
- Open cooling water system valves.

- ⇨ Turn the compressor flywheel by hand (one turn).
- ⇨ Start the motor, after draining the moisture shut the drain valve.
- ⇨ Check the motor ampere consumed.
- ⇨ Check the pressure gauge readings.
- ⇨ Frequently drain the moisture.
- ⇨ When charging full, open drain valve and stop the compressor

10. How do you check compressor efficiency @ running ?

- ⚓ Checked by *filling time* with the previous record and also check the *first stage discharge pressure*. If compressor efficiency is lower, compressor will run longer and compressor temperature will rise.
- ⚓ First stage and second stage pressure gauge must be correct and stabled
- ⚓ No escape air from suction filter
- ⚓ Intercooler and after cooler outlet air temperature should not be high
- ⚓ If open drain valve nothing can found
- ⚓ Low L.O consumption
- ⚓ Oily air mixture must not blow out from breather pipe.

11. Safety devices on main air bottle ?

- ⇨ Pressure relief valve.
- ⇨ Fusible plug.(if safety valve is not directly fitted on the bottle)
- ⇨ Pressure gauge.
- ⇨ Low air pressure alarm.
- ⇨ Moisture drains valve.

12. Where is the fusible plug fitted ? Purpose ?

Fusible plug is fitted under side of the pipe between relief valve and air bottle.

It is fitted to release the compressed air in the event of abnormally high compressed air temperature. Fusible plug melt at 105 °C and release all content of air. It is made by 50% Bismut, 30% tin, 20% lead.

A fusible plug is fitted after the second stage cooler to limit the delivered air temperature and thus protect the compressed air reservoirs and pipe work.

13. Can you fit the relief valve at the space of bursting disc and why ? *****

At the compressor, relief valve can not be fitted at the bursting disc, because of their difference operation.

Bursting disc is fitted for totally release and stop operation circuit.

Release valve opens excess pressure at compressor running and reseat at when pressure reduce or when the compressor is stopped. Thus cooling water can enter to compressed air space; it can cause water hammer when the next start of compressor.

14. What is volumetric efficiency ?

It is the ratio of the actual volume of air drawn in each suction stroke to the stoke volume.

$$\text{Volumetric efficiency} = \frac{\text{Actual volume of air drawn in suction stoke}}{\text{Volume of air for stoke volume}}$$

FACTORS AFFECTING VOLUMETRIC EFFICIENCY

1) The bumping clearance (the larger the bumping clearance the less air is discharged per stroke)
2) Sluggish opening and closing of suction and delivery valves
3) Leakage past compressor piston rings.
4) L.P inlet air temperature too high
5) L.P inlet filter dirty and choked
6) Inlet cooling water temperature too high
7) Insufficient cooling water owing to fouling of coolers

15. Difference between intercooler and after cooler ?

Intercooler

- ⇨ Fitted intermediate stages.
- ⇨ Saving in power.
- ⇨ Increase volumetric efficiency.
- ⇨ Reduce temperature for next stage and it can avoid a danger of explosion in compressor cylinder.
- ⇨ Can provide good lubrication of the compressor piston.
- ⇨ No carbonized material form of discharge valve.
- ⇨ Moisture separation is easier through intercooler drain.

After cooler

- ⇨ Fitted at the final stage discharge side.
- ⇨ Reduce final discharge air temperature to room temperature.
- ⇨ Increase volumetric efficiency.
- ⇨ Air bottle size is smaller.
- ⇨ Moisture separation is easier through after cooler drain.

16. Why need bumping clearance ?

This is a clearance must be provided between the piston top and the cylinder head when the piston is top dead centre. it must be kept as small as possible for achieving the best compressor efficiency.

- ⇨ To prevent mechanical damage to the compressor.
- ⇨ To provide for thermal expansion and
- ⇨ To provide necessary space for valve operation.

17. How to adjust the bumping clearance ?

It can be adjusted by two ways.

- ⇨ By altering the head gaskets (cover joint) thickness,
- ⇨ ~~By adding and subtracting shims between the connecting rod food and bottom and bearing.~~

18. Main air compressor bumping clearance taking procedure ?

- Stop the compressor and (lock off) take out fuse.
- Drain the cooling water.
- Remove the cylinder cover.
- Clean the cylinder head face and piston crown.
- Place the lead wire ball on the top face of the piston. That is larger size than expected by clearance.
- Cylinder cover is placed on the cylinder with correct joint thickness and tightens the head bolts.

- Turn the compressor slowly by hand over top centre so that lead wire ball is pressed.
- Then remove cylinder cover again.
- Remove the compressed lead wire ball.
- Take the measurement of lead wire thickness by using micrometer.

19. At what condition fusible plug is fitted main air bottle ?

Fusible plug is fitted at main air bottle, when relief valve is fitted indirectly to the air bottle. It can cause any obstruction by human error.

20. Purpose of bursting disc? Where is fitted ?

It is fitted on each cooler shell of air compressor, to give ample relief of pressure when cooler tubes burst.

21. Why bursting disc need to be annealed ?

Due to heating and time expanded bursting disc is harden so to get back the normal relief pressure . It must be annealed.

22. First start arrangement ?

- Firstly start the emergency air compressor to fill up the air to the emergency air bottle up to desired pressure obtained.
- Drain out oil and water.
- Open emergency air bottle outlet valve and pressed up desired pressure.
- Then start the generator with correct procedure.
- Close the breaker and switch on the lighting.
- Start the required machinery (especially G/E FO booster pump, S, W cooling pump, E/ R blower).
- Start the main air compressor and press up to main air bottle.
- After that, made M/E warming by using generator jacket water and start the L.O pump.

23. Why provide air compressor on board ?

(1) Starting Diesel engines,
(2) Instrumentation and control systems,
(3) Various pneumatic tools and cleaning equipments,
(4) Boiler soot blowing and
(5) Ship's whistle.

24. Why need minimum lubrication ?

- To prevent carbonizing of the valves
- To avoid loss of compressor efficiency due to sluggish action of valve
- To avoid loss of cooler efficiency due to deposition of oil on the cooling surface
- To prevent air line explosion, to prevent air bottle corrosion

25. **VALVES LEAKING**

Valves can leak and finally fail. Valves may fail owing to wear and fatigue, insufficient of over-lubrication, presence of foreign particles, oil decomposition and excess valve lift.

EFFECTS OF VALVES LEAKING

First stage suction

1) Reduce air delivery
2) Reduce second stage suction pressure
3) Increase running time
4) Unload the compressor

First stage delivery

1) Reduce delivery
2) Increase discharge temperature
3) Less air drawn in due to high pressure air leaking back into the cylinder

Second stage suction

1) High pressure in suction line of 2 nd stage
2) High temperature in suction line of 2 nd stage
3) Reduce delivery
4) Increase running time

Second stage delivery

1) Increase suction pressure in2nd stage
2) Reduce delivery in 2nd stage
3) Increase delivery pressure from 1st stage

26. FALLS OF COMPRESSOR PERFORMANCE

(Causes of poor performance)

(01) Choked air suction strainer
(02) Leaky or sticky valves
(03) Too much L.P bumping clearance
(04) Leaky piston rings
(05) Leaky cover and gaskets
(06) Leaky drains
(07) Leaky relief valves
(08) Leaky coolers
(09) Worn crankpin or bearings
(10) Faulty capacity controller

How to maintenance air compressor efficiency ?

1. Cleaning of suction air filter
2. Adjusting bumping clearance
3. Regular overhaul the suction and delivery valve and checking bearing
4. Check the piston rings and liner
5. Clear the cooler drain free from deposits
6. Clean the cooler

Air bottle pressure test

01) Gag the relief valve
02) Close all openings
03) Fit test pressure gauge
04) Remove filling valve and fill F.W completely
05) Air purge and connect hydraulic pump at filling line.
06) Apply pressure 1.5 times of working pressure and maintain at least 30 min
07) Check leaking points.

Purpose of drain valve (Compressor and Air bottle)

It is process to remove the accumulation of oil water and sludge from the air bottle, scavenge space, compressor intercooler and settle and service tank.

01) To drain the water and surplus oil in the air bottle.
02) To avoid air bottle corrosion
03) To prevent staring air line explosion and sluggish & corrosions system valve.

PURIFIER

1. What is gravity disc ?

The gravity disc is important part of purifier, which set the location of the oil, and water interface line, which is variable according to the maker's design.

2. How to choose the correct size of gravity disc ?

1 can choose it. Separation temperature **2.** density of oil at this temperature **3.** desired through put of oil and by using of nomogram .

3. What is paring disc ?

It is a stationary impeller mounted in a chamber at the neck of the bow.

It function is convert the rotating energy into a pressure head.

4. What about water washing ?

Water washing is widely used techniques to remove acids, salts, and other impurities from the oil.

The oil must be straight mineral oils or without dispersant additive oils.

Water should be injected into the oil before purifying at a rate of between 3 to 5% of the oil flow that is continuously renews the water seal in the purifier bowl.

The oil temperature should be around 75 °C and water temperature about 5 °C higher than oil .It can be done continuously or intermittently.

5. What is steam jetting ?

- ⇨ By blowing steam into the engine lube oil just pair to its purification.
- ⇨ Coagulation of colloidal carbon will occur.
- ⇨ Purifier will remove this carbon more effectively.

6. Compare purifier and clarifier ?

Purifier	***Clarifier***
a. Remove water and suspended Solids particles from oils	**a.** Remove finer and lighter particles from oil
b. Two outlets water and clean oil	**b**. one outlet for clean oil
c. Gravity disc on top	**c**. No gravity disc only sealing ring
d. Blind disc on the top of disc stack	**d.** Blind disc at bottom.
e. Sealing water required	**e.** Sealing water not required

7. How do you change purifier to clarifier ?

- ⇨ Open up the purifier and set the blind disc at the bottom of the disc stack.
- ⇨ The water outlet is blocked by a seal on the gravity disc.
- ⇨ Blank off the sealing water inlet line.

8. What is purifier, clarifier ?

- ⇨ Purifier is a centrifuge, which is arranged to separate water and solid impurities from oil.
- ⇨ Clarifier is a centrifuge, which is arranged to separate finer solid impurities from the oil.

9. How to change purifier from H.O to D.O ?

- ⇨ Replace the gravity disc, which is smaller than the heavy oil
- ⇨ Open heater by pass vale.
- ⇨ Closed the F. O heater steam in/out valves.
- ⇨ Open heater drains v/v.

Remarks. Pure D.O purifier cannot change to H.O, it has no heater.
Pure clarifier cannot change to purifier, it has no water outlet.

10. Why multidisc provided ?

- ⇨ To separate the liquid into thin layer & create shallow settling distance between discs.
- ⇨ Improving separation of oil from heaver liquids & solids particle

11. Cause of excessive vibration on purifier

- ⇨ Sludge too much
- ⇨ Foundation damper & spring failure
- ⇨ Bearing failure
- ⇨ Worn gear
- ⇨ Uneven wear of frictional clutch
- ⇨ Motor speed too high or too low

12. Explain purifier over flow

1. Incorrect purifier disc size (inside diameter too large)
2. Too low fuel oil temperature
3. Too much rate of throughput
4. Too much sludge inside the bowl
5. Low speed (rpm) of bowl rotation
6. Sealing water failure
7. Operating water failure
8. Worn out main sealing ring

Why have not get enough rpm when purifier is running ?

1. Improper touching with friction clutch (worn out frictional clutch)
2. Touching with break
3. Excessive sludge in the bowl
4. Bearing failure
5. Motor running at overload
6. One phase power failure (Single phasing)
7. Sump oil level too high
8. Vertical shaft and horizontal shaft are out of alignment

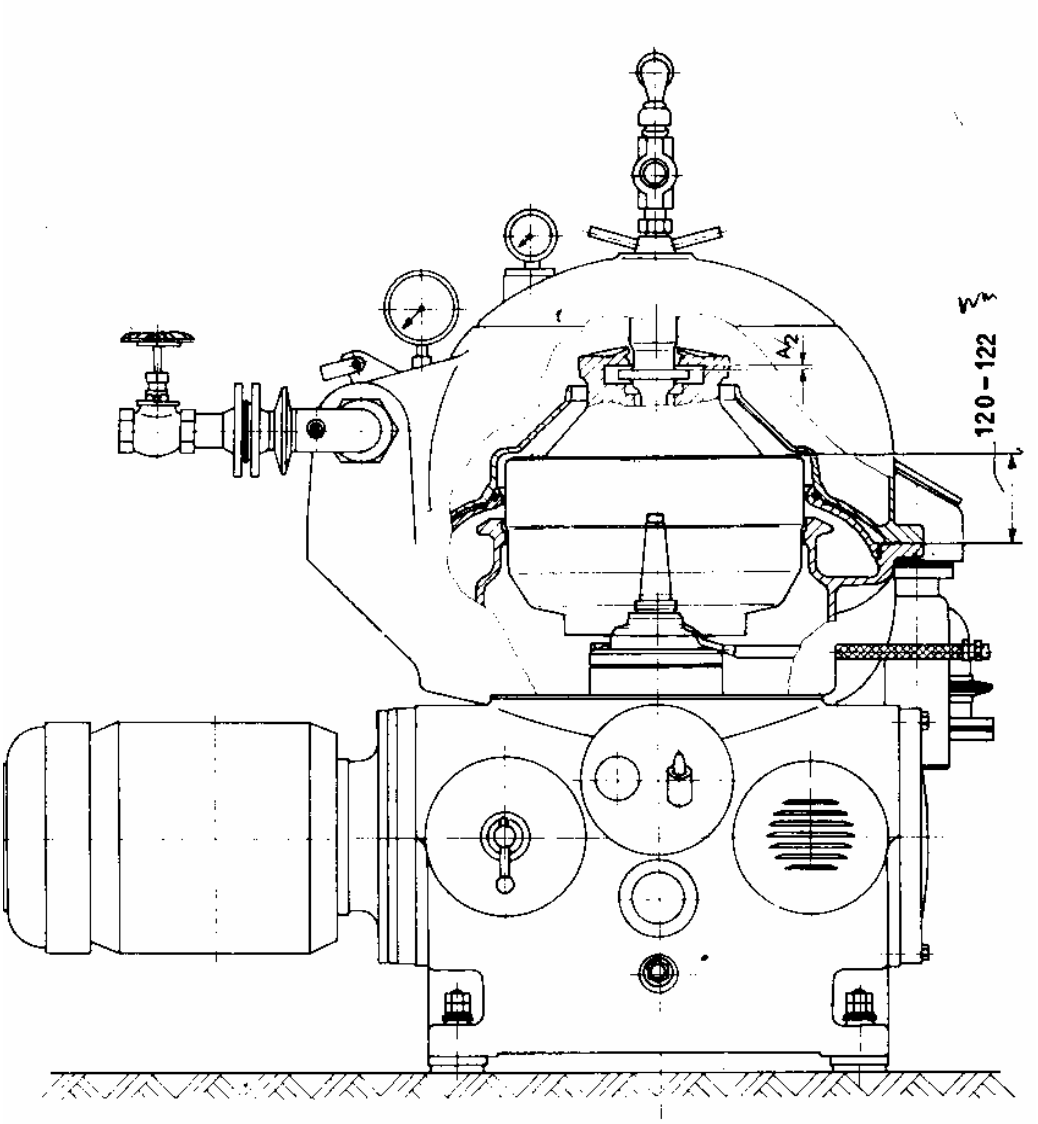
How to adjust bowl high ?

- By turning vertical shaft adjust screw
- By shim by bowl body

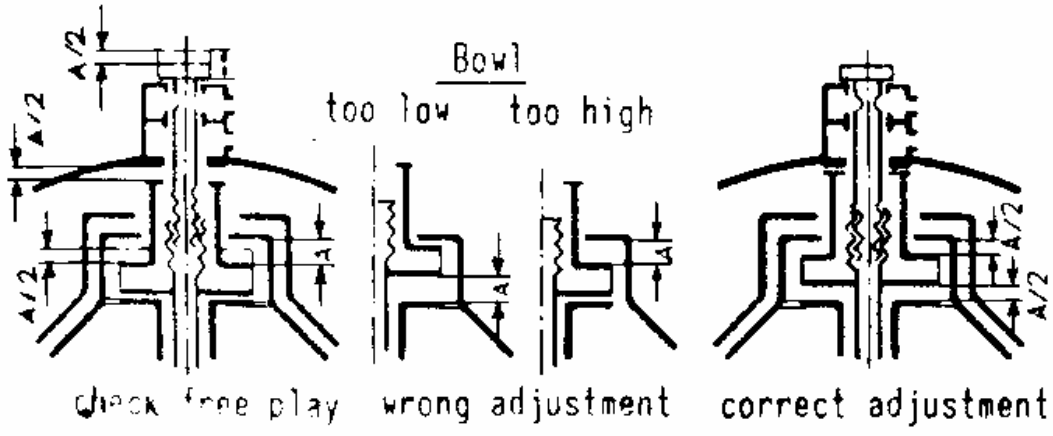
Reduce purifier bowl high → Oil goes through the water outlet.

Why need sealing water ?

To seal the water outlet & to prevent the overflow of oil from the water outlet.



Adjusting the Bowl height



Checking the play above and below the centripetal pump
WESTFALIA SEPARATOR

REFRIGERATION & AIR CONDITION

1. Safety devices on refrigeration system

1) *L. P cut-out on compressor suction side:* Set at a pressure corresponding to 5°C below the lowest expected evaporating gauge reading
2) *H.P cut-out on compressor discharge side:* Set at a pressure corresponding to 5°C above the highest expected evaporating gauge reading
3) *Lube oil low pressure cut-out:* Oil pressure usually set at 2 bar above crankcase pressure
4) *Cooling water L .P cut-out in condenser side*
5) Safety *spring loaded liquid shock valve* on compressor cylinder head
6) *Bursting disc* on cylinder head, between inlet and discharge manifold
7) *Bursting disc* on Condenser, [if fitted]
8) *Relief valve on* Condenser; air purging valve on condenser
9) *Master solenoid valve*: to prevent liquid being entered into Compressor, when the plant is standstill, especially in Large Plant

2. What is critical temperature ?

Critical temperature above which it is impossible to liquefy the refrigerant regardless of pressure.

It should be as high as possible and certainly above the maximum expected condenser temperature.

3. What is the primary refrigerant ?

It is a medium which is used in a vapour compression cycle to remove heat from a low temperature region and convey it to a high temp: region .It undergoes change of physical state during its working cycles.

1) Mostly volatile liquid and employed inside direct expansion closed system.
2) Evaporate at low temperature and at reasonable pressure
3) Condense at SW temperature at reasonable pressure

4. What is secondary refrigerant ?

It is a substance which is transferred heat by conduction and convection. Brine is a secondary refrigerant .Its density 1250 kg /m2

1) It is a non volatile liquid during it working cycle and employed at large, complex installation, to avoid circulation of expansive Primary Refrigerant in large quantities.
2) Cooled inside Refrigeration Machinery Room and pumped around the ship to batteries in each cargo space

5. What is solenoid valve? How to operate? Why fitted ?

- ⇨ Solenoid valve is a liquid stop valve.
- ⇨ The valve is fully open and close.
- ⇨ To control the cool room temp: within set limit
- ⇨ It is a electro magnetic cut in cut out devices when the cool room temp reaches the desire point, the pressure switch which is connected to the thermo bulb in the cool room shut the solenoid valve which stop the refrigerant flow into the evaporator.

6. What is the function of thermostatic expansion valve ?

1) To control the flow amount of liquid refrigerant to the evaporator in such a way as to keep practically the entire coils filled with the evaporating refrigerant.

2) To keep constant super heat on the refrigerant vapour leaving the evaporator.

3) It sudden drop in pressure and temperature

⇨ Automatic and prompt responds of refrigerant flow to match the Evaporator Load.

⇨ Prevention of Liquid Refrigerant being entered into the Compressor.

⇨ Maintaining appropriate amounts of Refrigerant in the High pressure side and Low pressure side of the system.

7. What is relative humidity ?

Ratio of amount of water vapour in given volume of air, to maximum amount of water vapour that can be present before precipitation occurs.

It is the mass of water vapour per unit volume of air compared to the mass of water vapour per unit volume of saturated air at the same temperature.

8. What is saturated air ?

The air contains maximum wt of water vapour at the particular temperature.

9. What is super heating ?

Temperature above which the saturated temp:

10. UNDER CHARGE

Symptoms

⇨ Low discharge pressure

⇨ Large bubbles in the liquid sight glass

⇨ Compressor delivery temp: high.

⇨ The machine runs for longer periods between cut out.

Remedies

⇨ To charge the refrigerant until the bubbles disappears in the liquid sight glass and charging will correct the pressure gauge reading.

⇨ To find out the leaky points by halide torch or soap solution or electronic leak detector.

11. OVER CHARGE

Symptoms

⇨ It is indicated by high compressor discharge pressure.

⇨ Compressor runs cold.

⇨ Excess frost on compressor suction line after evaporator.

⇨ Full of sight glass.

Remedies

The excess refrigerant is released to atmosphere through the purging valve fitted on the condenser until discharge pressure return to normal.

12. AIR IN THE SYSTEM

. ***Symptoms***

⇨ High condenser and compressor temp:

- ⇨ Abnormally high discharge pressure
- ⇨ Jerky pointer gauge
- ⇨ Very small bubbles in liquid sight glass.

Remedies

To remove the air from the system –

- ⇨ Change the compressor to manual position
- ⇨ Closed the liquid stop valve after the condenser
- ⇨ Pumping down the entire charge into the condenser
- ⇨ Until the suction pressure just above zero.
- ⇨ Stop the compressor and closed the consider inlet valve
- ⇨ Then allowed to cool the consider contents.
- ⇨ Air is expelled through the purging valve until the refrigerant gas appears at the valve.

13. MOISTURE IN THE SYSTEM

Symptoms

- ☞ Starving of evaporator and rapid condenser pressure rise cause compressor short cycling.
- ☞ Frost at expansion valve inlet.

Remedy

- ☞ Clean expansion valve filter.
- ☞ Renew drying agents of dehydrator.

14. Cause of expansion valve chocking

When a valve is functioning correctly frost forms on the outlet side of the valve, and if the inlet side does show frosting then this is a sign of blockage.

- ☞ It is caused by dirt or freeze up by water present in the system.
- ☞ Starving of evaporator and rapid consider pressure rise cause compressor **short cycling.**

Remedy

- ☞ Clean the expansion valve filter
- ☞ Renew the drying agent of dehydrator. (activated alumina or silica gel)

15. OIL IN THE SYSTEM

Symptoms

- ☞ Incorrect condenser and evaporator temperature differential.
- ☞ The system running longer than normal.
- ☞ Difficult to cold down room temperature.

Remedy

- 🛠 Pumping down the entire charge to condenser.
- 🛠 Along the system must be blown out with compress air by stripping individual unit component.
- 🛠 Repair the oil separator.
- 🛠 Renew the compressor piston rings.

Defective Suction valve

Indication

1) Continuous running of compressor
2) Insufficient cooling effects
3) Noisy operation

4) High suction pressure

Defective Discharge valve

Indication

1) Continuous running of compressor
2) Insufficient cooling effects
3) Noisy operation
4) High suction pressure during running
5) Low discharge pressure during running
6) Suction pressure faster after compressor is shut down
7) Warm cylinder head

16. How do take in action high pressure cut out and low pressure cut out ?

H. P pressure cut out

- ☞ Occurs due to condenser coolant failure, low coolant pressure and malfunction of consider cooler valve operation.
- ☞ Also can cause dirty or chocked condenser tubes.
- ☞ The refrigerant can not liquefy rapidly .The discharge pressure will abnormally raise and high pressure cut out will take in action.

Low pressure cut out

- ☞ Operate the solenoid valve is closed when the cool room temp: reach its desired temp: (setting temp:)
- ☞ Can cause when expansion valve is chocked by dirt or freeze up by water present in the system.
- ☞ Starving of evaporator and rapid condenser pressure rise.
- ☞ Compressor may stop by low pressure cut out.

17. Leakage Test for Refrigerant

CO_2 – Soap and water solution

NH_3 –Wet litmus paper (*Red ~ Green*); Sulphur candles, which gives off *white dense smokes* when contact with Ammonia

Freon – Soap and water solution / Halide torch /Electronic leak detector (buzzer sound)

By halide torch, How to indicate the flame ?

Content is methylated spirits type. Butane can also be used.

When the leak is detected the flame will change from blue to green depending on the concentration of gas.

18. What is refrigeration ?

It is a process in which the temperature of a space or its contents is reduced to below that of their surrounding.

19. What is air conditioning ?

It is the control of temperature and humidity in a space together with the circulation, filtering and refreshing of the air.

20. What is ventilation ?

It is the circulation and refreshing of the air in the space without necessarily a change of temperature.

21. Comfort zone ?

It is between the 40 to 70 % relative humidity at the temperature of 20 to 29C dry bulb temp:, air motion is 100mm per sec.

22. Advantages of secondary refrigerant ?

- Low initial cost
- Low maintenance cost
- Suitable for large refrigeration plant
- Easily produce onboard by mixing Ca Cl2 and distilled water.
- Easily store as a salt onboard

Defrosting

A method of removal of frost, built-up on Evaporator coils. Defrosting should be done before snow thickness exceeds ¼".

Reasons for defrosting

- Affecting heat transfer properties
- Affecting air flow and circulation
- Liquid back to compressor

23. Defrosting methods ?

- By stopping the system
- By washing with warm water
- By means of electric heater coil fitted at the evaporator
- By hot gas defrosting method

Defrost brine System

Hot brine thawing : Best and fastest method, used powerful brine heater with separate thawing system. Watertight trays under the pipes, collected the dripping water

Hot air from atmosphere : It is important that isolating doors in air trunks are perfectly tight, so as to prevent hot air going into cargo spaces.

By shutting off brine : Allow the snows to be melted by the heat of the heat of the air in circulation .Very slow operation and tends to throw back great deal of moisture into cargo space.

Notes:

Direct expansion grid system : Hot gas defrosting
Battery cooling system : Water spray, electrical or steam heater
Brine cooling : Hot brine thawing

24. Purpose of ventilation for cargo hold ?

- To remove surplus heat and humidity
- To prevent the condensing of moisture on cargo or hull
- To remove gases produced in ripening process of some fruits and vegetables cargos.

25. What is short cycling ?

It is a condition of a compressor unit repeatedly running for a few second and then cutting out .This is the result of L.P controller.

26. Why fitted high pressure cut out ?

It is fitted to shut down the compressor in the event of high pressure .After remedy the fault, have to run necessary to reset.

27. Why fitted master solenoid valve for large plant ?

If compressor stops due to a fault, the master solenoid valve will close to prevent flooding by liquid refrigerant and possible compressor damage.

28. Explain about one method of refrigerant charging ?

Normally charging is made through the liquid charging valve at the high pressure side.

01). Firstly, weighting the gas bottle.
02). Connect the gas bottle and charging valve with the connection pipe.
03). Before tightening the cap on charging pipe, open bottle valve to remove air in the pipe.
04). Then tighten the cap and open bottle valve fully, charging valve is still closed.
05). Change compressor to manual running and start it.
06). Close the condenser outlet valve.
07). Pumping down the entire charge to the condenser.
08). Open the charging valve slowly when suction pressure just above zero.
09). Control the valve opening slowly that no frost formed on the compressor suction pipe.
10). Check the level in the condenser sight glass.
11). Close the charging valve and pumping down the entire charge until suction pressure just above zero.
12). Stop the compressor and close the discharge valve.
13). Cooling water kept running for some hour.
14). Then air is purged out through purging valve on condenser until the refrigerant gas appear at the valve.
15). Calculate the amount of refrigerant (charging) and enter the engine log book.

29. Why super heat is required at evaporator outlet ?

⇨ To prevent the liquid refrigerant entering into the compressor.
⇨ If no super heat, hammering may happen and the valve will suffer damage and breakage.

30. How to fill fridge plant compressor oil ?

01) Change the compressor to manual running.
02) Pumping down the entire charge to condenser.
03) Connect the L.O hand pump to L. O filling valve after air is purged out.
04) When compressor suction pressure just above zero, open the oil filling valve, inject the L.O into crank case.
05) Then stop the compressor and close compressor discharge valve. Then cool down the refrigerant.
06) Then purged out the air through the purging valve until refrigerant appears at purging valve.

31. Types of expansion valve.

- Thermostatic control
- Electronic control
- Manual control

32. Prevention of Liquid Flow Back

2) Liquid shock valve (on cylinder head0
3) TEV
4) Master solenoid valve (when the plant is standstill, especially in Large plant)
5) Defrosting
6) Bursting disc (on cylinder head, between inlet and discharge manifold)

Back pressure valve at the outlet of vegetable room to prevent under cooling of coargo.

AIR CONDITIONING

Objectives

(01) To extract excess heat
(02) To raise air temperature when required
(03) To add moisture as required
(04) To reduce too great a moisture content as required
(05) To maintain sufficient Oxygen and air flow
(06) To remove dust

Control of Temperature

Comfortable temperature range is about 22 °C and RH about 60% (usually 40 ~ 70%)

All zone temperature

1) Controlled by compressor suction pressure, via solenoid valve as step controlling.
2) Thermostat, placed at some accommodation space actuates the Master Solenoid Valve of the plant, which will stop the Compressor, when pre-set temperature is reached
3) Capacity Unloader of compressor units, does last step controlling, as required

Particular zone temperature

1) Controlled by flap valve fitted in each zone loop
2) Local cabin temperature can be adjusted by volume control at delivery point of air duct controller.

Ozone depletion.

Ozone is gas; between 15 & 30 kilometer above the surface of earth.

This layer controls our climate & protects us from radiation. The release of industrial waste and other process are now increasing the ozone breakdown to disturb the natural balance.

How ozone is destroyed.

Pollutant (e.g. - CFC) gas from ground level travel to atmosphere.

In the upper atmosphere Ultra Violet Ray breaks off Chlorine atom from the CFC molecule.

The free chlorine atom attack the one ozone molecule. Breaking it form to chloromonoxide. The remainder of the ozone molecule formed into regular oxygen molecule.

A free oxygen atom now steels the oxygen from chloromonoxide molecule form an oxygen molecule. Chlorine atom is again free, attack and break up an ozone molecule. In this way single chlorine atom destroy 1 million of ozone molecule.

Ozone depletion ~ More ultra violet radiation ~ Global warming, Increasing skin cancer, immune system affected, reduced forest production and crops & sea ecology disturb.

More green house gas ~ Warmer & more humid climate ~ more desert, less forest, agri: problem, higher sea level, sea ecology system destroy. (When the concentration of CO_2 & other gases increases)

Refrigerant effected to Ozone layer. ~ R11 ($CClF_3$), R12 (CCl_2F_2), R22 ($CHClF_2$)
Refrigerant not effected to Ozone layer. ~ NH_3, R134A

HEAT EXCHANGER

What is Charge Air Cooler purpose ?

- To reduce air temperature & increase density of charge air.
- All more fuel can be burnt more power can be obtain
- Reduce exhaust temperature and engine thermal load.
- Increase scavenging efficiency, safe working temperature.

Cooler maintenance for optimum efficiency

1. Cooler should be checked any deposit of line, scale or oil sludge may be present in cooler it should be cleaned.
2. Cooler of water side can be done with soft tube brush and oil side with carbon tetra chloride solution in reverse direction to normal flow with hand pump for about 4 hours.
3. After cleaning the cooler are hydraulically pressure tested normally 1.5 times the working pressure.
4. It 10% of the tubes have been leaked retubing in necessary. Normal leaking tubes may be stopped by plugging.
5. Corrosion can be protected by means of preservative coating (Anti corrosive paints) inside the shell and water boxes and by means of anodes such as zinc fitting inside water boxes.
6. Essential cooler for optimum efficiency can be maintained by controlling of temperature of fluid or sea water.

Purpose of division plate

1. To providing to increase numbers of pass
2. This increase the cooling efficiency.

What do you know L.O cooler leakage ? How to do L.O cooler leakage occur ?

When engine run,

01) Oil comes out at the cooling water overboard.
02) Sump tank oil level will fall down.
03) L.O pressure will drop
04) If L.O cooler leaks the engine should be stopped with permission from bridge. The leakage can be detected by carrying out a hydraulic pressure test to the oil side.
05) After cooling down the engine stop main circulating L.O pump and main S.W cooling pump.
06) Close necessary valve of them
07) Open water box covers cooler both side.
08) Blank off discharge pipe of cooler oil side.
09) Connect hydraulic pump to inlet of cooler.
10) Apply oil pressure normally 1.5 times the working pressure. Then check the leakage at cooler both sides
11) Normally leaking tubes may be stopped by plugging
12) If 10% of the tubes have been leaked retubing is necessary.
13) Then the engine is put back normal running.

How do you know air cooler leakage ?

01) Check water level insight glass fitted at cooler drain pipe.
02) Drain the cooler / taste the water
03) If the water continuous comes out, the cooler is leakage. Also in the funnel white & dense smoke.
04) Thus the engine should be stopped with permission from bridge.
05) Normal leaking tubes can be stopped by plugging.
06) Then the engine is put back normal running.

How to check cooler efficiency ?

01) Check sea water in/out temperature difference. Less amount poor efficiency of cooler (must be high)
02) Check coolant medium in / out temperature (Difference temperature: should be low)
03) Feel over cooler shell, upper →hot, middle →warm, down →cool is normal.
04) Check pump and by pass valve.

Purpose of baffle plate
01) To prevent the tube
02) To guide the flow of fluid
03) To increase cooling surface area
04) To minimize the tube vibration

Cause of loss of vacuum effect in F.W.G

(01) Failure of ejector pump
(02) Failure of ejector nozzle (fouling, erosion)
(03) Malfunction of check valve (at ejector nozzle)
(04) Defective vacuum breaker
(05) Any air leakage into the system (At joint)

What will happen while vacuum reach 100%

1) Increase the salinity because of agitation. AT that time boiling rate is very high.
2) To control this condition: I open the vacuum breaker to maintain 93% vacuum.

Why F.W.G is fitted onboard ship ?

1) To produce the high purity distilled water from sea water
2) To provide make up water fro boiler and portable water for drinking and domestic used. So can save cost.

Treatments for drinking purposes.

Sterilizing methods.

- Chlorination.
- Ultra violet light.
- Libration of silver ions from the consumable.

Improving the platability.

Osmosis.

Different concentration solutions are separated by a semi-permeable membrane. Water from less concentrated solution pass through the membrane to equalize the concentration of the two solution. It create hydraulic pressure gradient across the membrane as the volume and level of weaker solution fall and those of the stronger solution rise.

Reverse osmosis.

The pressure greater than the osmotic is applied to the side of higher concentration, the process is reversed. Water from the stronger solution is forced back through the semi-permeable membrane to dilute the initially weak solution on the other side and further increase the concentration of the strong solution.

The total pressure required for this process consists of the osmotic pressure(between 4 bar for brackish water up to 28 bar for sea water) plus the system pressure losses and net driving pressures (around 25 bar).

Membranes

1. Hollow fine fiber (aromatic polyamide or cellulose acetate spurn to form hollow fiber)
2. Spirally wound (cellulose acetate for backish water and polymide or polysulphonate for sea water.)

STEERING GEAR

Type of Telemotor System

1) Hydraulic system
2) Electric system

Type of Steering system

1) Elector hydraulic system
  a) Ram type system (2 ram or 4 ram)
  b) Vane type system
2) All electric system
  a) Ward Leonard system
  b) Single motor system

Non follow up system.

When steering gear set to required position, rudder is moved & when rudder reach the required position, steering gear must be set to off position. This system uses the three solenoid valve.

Follow up system.

When steering gear set to required position, rudder is moved & when rudder reaches the set position, steering gear still remains at that position. This system uses the hunting gear arrangement.

2. What is hunting gear ?

It is feed back mechanism of steering gear which repositions the floating lever of hydraulic pump as the tiller moves to the desire position.

3. Safety devices for steering system ?

- ⇨ Hunting gear
- ⇨ Buffer spring
- ⇨ Angle adjusting stop (Hand over position limit switch)
- ⇨ Double shock valve
- ⇨ Relief valve
- ⇨ Tank level alarm (oil)
- ⇨ Over load alarm

4. Indication of air in the system

- ⇨ Jumping pressure gauges
- ⇨ Jerky operation
- ⇨ Defective steering

5. Effect of air in the system ?

Air being compressible gives incorrect balance between units, time lags and irregular operation. (which can be dangerous)

6. Emergency steering gear operation?

In the case of Telemotor failure, by switching the change over pin, Emergency steering can be carried out by isolating the Receiver Cylinder and directly controlling the connecting rod of the Main Steering Power Unit's pump lever.

The emergency Rudder angel indicator and communication system to Bridge being provided at the Emergency station.

In case of electrical telemotor failure

- Put bridge control to manual
- Emergency steering gear system is operated by (solenoid button) whether port or starboard. Rudder angle indicator and communication system between steering room and bridge must be provided.

Emergency steering gear operation.

1. Disconnect auto pilot system.
2. Took out change over pin from attachment with telemotor receiver & fit to the hand gear.
3. Communication system with telephone from steering gear room to bridge.

Steering gear test & maintenance.

Control test - Just prior to 1hour before departure of vessel.

12 hour before departure.

- Operation of main & auxiliary steering gear.
- Operation of remote control system.
- Operation of emergency power supply.
- Alarm test.
- Actual rudder angle & indicator.
- Communication system.(Bridge, Engine room & Steering gear room)

Every 3 months interval.

- Emergency steering gear drill at steering gear room to bridge with sound communication system.

7. Types of pump used in hydraulic steering system ?

Motor driven constant speed variable stroke delivery pumps. There are two types.

- ⇨ Radial piston type (hele- shaw pump)
- ⇨ Axial piston type (swash plate pump)

8. Advantages of rotary vane type over ram type ?

- ⇨ Smaller space required
- ⇨ Law installation cost
- ⇨ Low in weight
- ⇨ Smaller power required, for the same load, because it can transmit pure torque to the rudder stock.

9. Disadvantages

Synthetic rubber backed steel sealing strips at vane tops are not strong enough for large ship gear.

Can be used for rudder stock ratings of about 1700 KNm and less torque generated by two ram is 120 to 160 KNm and for four ram 250 to 10,000KNm.

10. Test required before departure ?

Steering gear should be checked at least one hour prior to departure.

- ⇨ Telemotor transmitter oil level to be checked
- ⇨ Oil level of actuating system tank should be checked and replenished if necessary.
- ⇨ Rudder carrier bearing and bottom sea gland checked and greased.
- ⇨ Start pump and check response of the gear

- ⇨ Check abnormal noise and heat
- ⇨ Check load carrying and running of the gear
  (swing from port 35 to STB 30 within 28 sec)

11. Properties of telemotor hydraulic fluid ?

Good quality mineral lubricating oil is used.

Its properties are-

- ⇨ Low pour point (-50°C)
- ⇨ Low viscosity (to reduced fractional drag, but not too thin to mate gland sealing, 30 Redwood Secs at 60°C)
- ⇨ High viscosity index (110)
- ⇨ High flash point (150°C closed)
- ⇨ Non sludge forming
- ⇨ Non corrosive
- ⇨ Good lubricating properties
- ⇨ Specific gravity 0.88 at 15.5°C

12. Purpose of buffer spring ?

To prevent the damages of the control system.

13. Requirements for steering gear ?

- ⇨ To move the rudder in either direction instantly when required
- ⇨ Should come to reset immediately in the position corresponding to that shown on indicator on the bridge.
- ⇨ Provision must be made to protect the steering gear from damage should a heavy sea strike the rudder.
- ⇨ The design should be sample, the construction robust and its performance reliable at all times.

14. Purpose of swivel block ?

To control linear movement of the rams to the rotary movement to the tiller arms and rudder stocks.

15. Explain ward Leonard system ?

It is the one types of electrical steering gear system. Which control the speed of DC motor from zero to maximum in either directions.

16. In four rums type steering gear system, what unit you make in service when one cylinder damage ?

If one cylinder damage, four rams steering gear can be used as two rams type steering gear.

First place the rudder at mid position. Isolate the circuit valves of two cylinder inlet.

One cylinder is defective and another one, but they are not in diagonal position. Open the vent at that cylinder.

17. Purpose of buffer spring ?

a. Absorb the difference between the steering order speeds and follow up speed.
b. Absorbed the movement of steering wheel if it is mishandled when the hydraulic pump stop in.
c. Absorb the movement of the control lever when rudder drift
d. Absorb the vibration and shocks from the rudder.

When carry out emergency steering system ?

⇨ Every voyage (UHA)
⇨ Once at least within 3 Months (SOLAS)
⇨ @ Survey

Daily check in steering gear room

- Pressure gauge of steering pump.
- Motor ampere on the steering switch board & motor hand touch feeling
- Noise and vibration.
- Oil level in tank
- Oil leakage in system
- Grease in rudder carrier bearing
- Check the bottom seal gland whether good or not.

Steering system regulation.

☑ Every ship shall be provided with a main steering gear and an auxiliary steering gear. The failure of one of them will not render the other one inoperative.
☑ Relief valves shall be fitted to any part of the hydraulic system.
☑ The main steering gear and rudder stock shall be:
A of adequate strength and capable of steering the ship at maximum ahead service speed.
A capable of putting the rudder over from 35' on one side to 35' on the other side with the ship at its deepest sea going draught and running ahead at maximum ahead service speed and, under the same conditions, from 35' on either side to 30' on the other side in not more than 28 seconds.
A So that they will not be damaged at maximum astern speed.
☑ The auxiliary steering gear shall be:
A of adequate strength and capable of steering the ship at navigable speed and of being brought speedily into action in an emergency.
A capable of putting the redder over from 15' on one side to 15' on the other side in not more than 60 seconds with the ship at its deepest seagoing draught and running ahead at one half of the maximum ahead service speed or 7 knots, whichever is the greater.
☑ In every tanker, chemical tanker or gas carrier of 10,000 gross ton and upwards and in every ships of 70,000 gross ton and upwards, the main steering gear shall comprise two or more identical power units.

Essential requirement for steering gear.

a To move the rudder in either direction instantly, when required.
a Should come to rest immediately in the position corresponding to that shown on indicator.
a Provisions must be made to protect the steering gear from damage should a heavy sea strike the rudder.
a The design should be simple, the construction robust and its performance reliable at all times.

Tests required before departure.

a Steering gear should be checked at least one hour prior to departure.
a Telemotor transmitter oil level to be checked.
a Oil level of the actuating system tank should be checked and replenished if necessary.
a Rudder carrier bearing and bottom sea gland checked and greased.
a Start pumps and check response of the gear.
a Check load carrying and running of the gear.

GOVERNOR

1. What is governor ?

Governor is a device which controls the speed of engine automatically in the prescribed limits.

The governor does its job in two steps.

a. measuring the speed and
b. control the a amount of fuel supply to the engine.

2. Function of governor ?

To adjust the rate of fuel supply in such a way as to keep the engine running at a steady speed regardless of the load .

To control the engine running at a steady speed under all conditions of load.

3. What is governor droop?

When considering the engine and governor combination, *the difference between the no load speed and full load speed* is called governor droop.

Small droop → rapid swing
Large drop → slower response to change in speed.

4. Types of governors.

a. Mechanical governor.
b. Hydraulic governor
c. Inertia governor [fitted on older slow speed engine]
d. Electronic governor

5. What is compensation ?

The use of temporary speed droop to prevent over correction of the fuel supply is called compensation.

It required two actions-

a. Droop application - as the fuel supply is changed
b. Droop removal - as the engine response to the fuel change and returns to original speed .

6. What types of governor used in G/E and M/E ?

G/E governor is a droop speed governor with over speed trip.

M/E governor is a constant speed governor with over speed trip.

7. Why fitted over speed trip in main engine ? *****

It is fitted to control the sudden load change and sudden increase in speed. e.g severe load change when loss of propeller in heavy sea .Thus, to prevent engine parts damage, over speed trip is provided.

Set the speed 15% more than MCR. It is attached at camshaft through gearing.

If engine speed rise more than 10 to 15% above the rated speed, It shut of fuel & stops the engine. The mechanism has to be manually reset before engine start again.

8. Why hydraulic servo governor is widely used ?

Hydraulic governor is widely used because of their

a. sensitivity
b. isochronous and
c. having grater power to move the fuel control mechanism of the engine .

9. What is hunting ?

It is a fluctuation of engine speed due to the over correction of the fuel supply. (too much increase or decrease fuel supply)

10. Cause of engine hunting ?

It is unavoidable time lag between the movement of the governor act and the movement of engine response.

11. What is isochronous governor ?

It is a constant speed governor .It is able to maintain exactly constant speed without hunting. This type of governor that has proportional and reset is called isochronous governor.

12. What will happen when over speed occurred ?

Engine revolving and reciprocating parts may damage due to inertia effects.

13. Why will you test G/E over speed trip ?

It can be tested by increasing the engine speed by speed adjuster at no load condition. Over speed trip will cut-out the fuel supply at 115% of normal speed.

14. Why speed droop governor is used at G/E ?

It is fitted to get load sharing ability isochronous governor gives constant speed, thus can not sharing the load.

AVR is fitted at alternator.

15. Why over speed trip provided although governor fitted ? ******

Governor only control the engine speed in prescribed limits. When accidental sudden load change that from full load to no load, engine speed become too high above 15% of rated speed.

Due to time delay of governor control, engine parts may become damage. Thus to prevent this effect over speed trip must be provided to shut down the engine by cutting fuel.

Note : it need to reset before restart the engine.

16. How to operate/act Isochronous governor ? *****

It maintains constant speed without hunting. Speed droop for it is temporary

It acts 2 actions

1. Droop application (as fuel supply is changed)
2. Droop removal (as engine responses to fuel change and returns to original speed)

Sensitivity : Ability to control the engine speed, within narrow limits

Stability : Governor is stable, when there is only one radius of rotation of flywheel for each speed, at which governor operates within the sped range.

17) Why Inertia type Governor is not used nowadays ?

1) Although very simple type, it requires an engine speed increase of 5% or more to make it operate

2) In some cases, increase of engine speed will bring into or near to critical speed that can cause severe vibration.

Governor Maintenance

- Periodically check oil level
- Change the governor oil
- Grease the linkage and joint

OVER SPEED TRIP Speed rise more than 10 to 15% above the full load speed, shut down the engine. Reset the engine before starting the engine.

OVER SPEED GOVERNOR Not effective certain limit up to 110% of normal speed. 10% above normal speed shut off fuel supply to engine and 5% below normal speed automatically recut in fuel supply to engine.

FIRE AND SAFETY

Class of fire.

A - Ordinary combustible material.
B - Flammable liquid & gases.
C - Electrical fire.
D - Metal fire.

Detector.

1. Combustible gas.	(Galley, ER fwd bulkhead adjacent to p/p room under floor plate)
2. Heat	(Galley, Boiler room, Laundry, control room)
3. Smoke	(Machinery space, Cargo space, Laundry, at stairways, corridor, escape route within Accommodation space)
4. Flame	(Engine room, near fuel handling equipment)

Fire tetra hedron.

Heat, oxygen, fuel, chain reaction.

Various medium used for fire fighting

1. Water : This is extinguishing mainly by cooling the material at fire. Steam generation is useful for smothering. Water is more suitable against fire in wood, paper and textiles.

2. Foam: The extinguishing effect of the foam is a combination of smothering and cooling. Foam is used against fire in oil surfaces.

3. Dry powder:The extinguishing effect of the powder is mainly by inhibition (change breaking) and effective mainly against fires in flammable liquid, gases and electrical equipment.

4. Carbondioxide: The extinguishing effect is smothering and inhibiting. CO_2 is heavier than air, the best condition for extinguishing is in closed spaces. CO_2 give no secondary damage. It is electrically non-conductor and therefore suitable against electrical equipment fire.

5. Halon: Extinguishing effect is nearly exclusively inhibition. Halons are suitable against fires in liquid and electrical equipment. All Halons are consider to be toxic to some degree because with hot surfaces and flame causes them to break down yielding toxic substances.

1. How many kinds of extinguishers in E/R ?

There are 3-kinds of extinguishers in E/R. There are foam, CO_2, and dry power types.

2. How do operate chemical foam extinguisher ?

It can be operated by releasing the cap by means of operating handle and turning it up side down. Aim to near the fire (base or wall). Shake the bottle foam coming out.

3. How to operate and extinguish the CO_2 extinguisher ?

Remove the safety pin and then the valve-operating lever is squeezed to pierce the disc. The liquid CO_2 leaves into the discharge horn and emerge as a cloud of CO_2.

4. What is emergency fire pump ?

It is a fixed emergency fire pump independently driven by self cooled compression ignition engine or an electric motor which power is supply from emergency generator. All the fire pumps out of action either by disabling the pumps or their source of power, it can be used.

5. Where emergency fire pump in your ship ?

It is fitted at steering flat, shaft tunnel, forward part of the ship.

The pump to be located remote from machinery space.

6. Requirements for emergency fire pump ?

Passenger ships of 1000 grt and upwards and in cargo ships of 2000 grt and upwards must have fixed emergency fire pump independently driven by a self cooled compression ignition engine or an electric motor driven by electric power from emergency generator.

- ⇨ It must be located *outside the E/R room*, in the steering flat, shaft tunnel or in forward part of the ship.
- ⇨ It must have own suction, total suction head should not exceed 4.5 meters under all conditions of list or trim.
- ⇨ Pump capacity must *not less than 25m^3/hr* and must be able to deliver two ½ inches bore jet of water having a horizontal throw not less than 40 ft.
- ⇨ Fuel tank for engine shall contain sufficient to run on full load for at least 3 hrs and reverse fuel for 15hrs, store outside the machinery space.
- ⇨ The prime mover engine at that unit must be hand started and able to start by one man.
- ⇨ If the pump is fitted above the water level, priming arrangement must be fitted.
- ⇨ If diesel engine driven:
  - Easily started in cold condition (0C by hand cranking
  - Fuel tank for engine shall contain sufficient to run on full load for at least 3 hrs and
  - Sufficient reverse fuel for 15 hrs, store outside the machinery space
- ⇨ If motor driven: emergency power supply heating arrangement

No. of Fire Pump

a Passenger ship of 4000 GRT and upward at least 3 pumps

a Passenger ship of < 4000 GRT and Cargo ship of 1000 GRR & above at least 2.

a Cargo ship of < 1000 GRT according to administration

7. What are the portable fire extinguisher used for? Where are they located ?

Portable fire extinguishers are the first line of defence.

It can be deal with an emergency as prompt action

All extinguishers should be:

01) Locate in an easily accessible Position

02) The correct type to deal with the class of fire expected in that area

03) Painted in the appropriate color code.

04) Regularly inspected and tested.

Water-signal red, CO_2 –black, foam- pale cream, dry power- franch blue.

8. Why do you make CO_2 room ventilation ? Where ?

To remove the leakage CO_2 from the CO_2 room .CO_2 gas is heavier than air and does not support to human life (Suffocate). (CO_2 room must be well ventilated before entry) Outside the machinery space usually at main deck and it must be separated compartment.

9. How to make it ?

It is made by motor driven exhaust blower or fan, which suction is drown from CO_2 room floor, because CO_2 is heavier than air and leakage CO_2 can accumulate on the CO_2 room floor.

Fan control switch is fitted outside the CO_2 room entrance.

10. How to extinguish control room small electrical fire ?

When E/R control room electrical fire breaks out, we must use CO_2 portable fire extinguisher, because CO_2 is electrical nonconductor.

01) First give the fire alarm signal.
02) Check the condition of fire and cut out the power if is possible.
03) Shut off E/R ventilator and close the E/R entrance door but one exit door must be opened behind me.
04) Take CO_2 portable extinguisher and fight the fire by staying up steam of air and the distance about 3-4 ft from fire.
05) Move back to the exit door.
06) Leave the extinguisher and close the exit door.

Carbon dioxide flooding system.

1) Steel cylinder, 67 liters capacity, each charged with 45 kg liquid CO_2 under pressure of 55 bar. Provided with safety disc, bursts at a pressure of 175 to 195 bar.
2) Quick release or total flooding cylinders are arranged that 85% of the capacity can be released within 2 minutes. Can be discharged individually.
3) Manual release cylinders for individual release.
4) Both groups are manifolds together.
5) The liquid when released produces about 450 times its original liquid volume in the gas form. One kg of liquid CO2 can produce 0.56 cubic meter gas.
6) To be effective in smothering a fire the **total carbon dioxide gas** to be obtained at least 30% of the gross volume of the largest room of the ship and the **total flooding system** must release to obtain 40% of the gross volume of the machinery space and held until the fire is out.
7) The visual and audible smoke detecting cabinet is located in the wheel house and two exhaust fans are installed in the water tight galvanized steel box on top of it. The three way valves, under the smoke detecting cabinet, are normally closed to CO_2 line and the blower sucks air from the holds through smoke detector will be closed and CO_2 can be discharged to the required cargo hold.

11. How to release the CO_2 gas from fixed instillation to machinery space ?

01) CO_2 flooding to machinery space must be done by master's order.
02) CO_2 must be released by competent engineer, CE or 2/E.
03) When cabinet door is opened alarm will sound and all E/R fans will be stopped.
04) Before releasing CO_2, all ER crew to be counted (No absence).
05) All openings must be shut (ventilator flaps, fire dampers).
06) All fuel pumps and quick closing valves of fuel tanks and fuel transfer line must be shut from remote control position.
07) After opening the cabinet door, master valve must be opened first.
08) Pull the operating handle of pilot cylinders.
09) CO_2 released from pilot cylinders, operate the gang release bar so that all CO_2 from quick release or total flooding cylinders will be released to machinery space.
10) By regulation, 85% of the capacity must be able to be released within 2 minutes.

Sprinkler or pressure water

The system consists of several sections comprising a number of sprinkler heads mounted on the pipes, each section being connected through a section control valve to a sprinkler main which in turn is connected to a pressure tank and a pump.

The entire system is initially charged with fresh water at a pressure of about 8 bar by a tank, maintained under pressure by compressed air. It is also connected to an independent sea water pump with its own sea water suction.

Each sprinkler head has a quartzoid bulb which retains a diaphragm seal in the outlet of the water pipe. This bulb is partially filled with a special fluid so arranged that a rise in temperature in the compartment concerned will cause the liquid to expand and entirely filled the space, the bulb burst, the water pressure forces the diaphragm out and water flow out from the sprinkler.

Under the specific pressure of 5 to 8 bar, maintained in the tank by air pressure, the water from the sprinkler is deflected upwards and outwards and broken into a fine spray by the serrated edge of the sprinkler base and will adequately cover a floor area of about 16 square meters.

The resultant pressure drop at the release of the water causes an alarm to sound on the bridge and indicates on the board, the zone in which the ruptured sprinkler heads are situated.

When the system pressure dropped to 5 bar, the sea water pump will start automatically and continue supply with sea water.

Each head must deliver 100 litters per minute. The number of heads in one section is limited not more than 200. They are spaced not more than 4 meters apart and 2 meter from any bulkhead or part of the ship's side which forms a boundary of the protected space.

Section alarms can be tested individually by test cocks on each section. At least two sources of power must be provided to operate the sea water pump and automatic alarms. The component should be tested weekly.

12. Sprinklers system requirements ?

01) Each sprinkler head must be capable of 100 lit/min.

02) Each sprinkler head is sufficient to cover the area of about 16 square meters.

03) One section is permitted to contain 150 to 200 heads.

04) Sprinkler heads are spaced not more than 4 meter apart and 2 meter from the vertical wall.

05) There must be at least two powers source for the sea water pump, alarm system and FW pump.

06) This system consists of independent S.W p/p with its own sea water suction.

07) Section alarm can be tested individually by test cock on each section.

Mechanical foam.

1) Foam is smothering agent. The production of this foam is mainly a process of agitation of a mixture of water, air and single foam compound, resulting in which is a vast and continuous bubble formation.
2) Foam compound is an aqueous solution of partially hydrolyzed keratin, stabilized with iron salts.
3) With modern foam making nozzles, the mechanical foam constituency can be varied from sloppy to stiff. Stiff foam has only blanketing quality. Sloppy foam has speed of smothering and additional cooling properties.
4) The expansion ratio is 30:1 water to foam compound, producing 200:1 foam to compound.
5) Quantity of the foam to give about six inches depth over the areas to be protected. The duration for the whole capacity discharge should be less than 5 minutes. The foam should not be disturbed too early and reignition may occur from the residual heat.

13. Differentiate between explosimeter and Davy's safety lamp ?

Explosimeter

- ⇨ To measure the consideration of inflammable gas and vapour in the atmosphere
- ⇨ Quickly and accurately.
- ⇨ It can measure remote from required tank.
- ⇨ It is necessary to skill full for operation.
- ⇨ Based on Wheatstone bridge principle.
- ⇨ No need to handle with care.

Davy's safety lamp

- ⇨ To detect the tank atmospheres, whether it is explosive gas or fatal gas.

- ⇨ It can get verify roughly the tank is gas free or not.
- ⇨ It is required to apply directly into the required tank.
- ⇨ Based on the ordinary fire process.
- ⇨ No need to highly skill.
- ⇨ But it required careful handling.

Davy's safety lamp.

Employed for detection of the tank atmosphere whether explosive or containing fatal gases.

1) If the flame in the lamp burn clearly, the tank atmosphere is free from any fatal or explosive gases.
2) If it is develops a faint blue cap above, it is the sign of an explosive gas present.
3) If the lamp burns black or goes out, foul gas such as carbon dioxide is present. The lamp will not burn in an atmosphere containing less than 16% of oxygen.

14. What are LFL and HFL ?

Lower flammable limit (LFL)

The concentration of hydrocarbon gas,1% by volume in air below which there is insufficient hydrocarbon gas to support and propagate combustion is Lower Flammable Limit.

Higher flammable limit (HFL)

The concentration of hydrocarbon gas inn air 10% by volume, above which there is insufficient air to support and propagate combustion.

It is a highest concentration of hydrocarbon gas in air for explosion.

15. Advantages of inert gas purging system ?

- ⇨ No explosive mixture can form in the tank.
- ⇨ Reduce corrosion.
- ⇨ Reduce pumping time because of the positive pressure in the tank at all the time.
- ⇨ Reduce the fire risk in the event of cargo loading, transporting and discharging.

16. FO setting tank (service) gas free procedure ?

- Drain down the entire charge into the double bottom tank through the dumping valve.
- When the tank is empty, open the manhole door which located one on top and other on side.
- Make force ventilation by blower fan through the manhole door at least 24 hrs.
- Then check the tank atmosphere by Davy's safety lamp.
- If the flame burns clearly, the tank atmosphere is free from explosive or fatal gas.
- Enter into the tank and clear the sludge and wipe out with cotton rags. During entering the tank ventilation must be provided continuously.
- One competent person must stand near the entrance to keep on watch.
- Use spark proof torch and lamp. Naked light and smoking not allowed in the vicinity.

Gas free procedure

01) Gas freeing is essential before entering empty. (Gas free certificate, Tank entry permit

02) Manhole doors to be opened for at least 24 hrs before entry.

03) Forced ventilation with air duct, to be done with electric blower for at least 24 hrs.

04) With forced exhausting system, minimum of 2 air changes should be completed during that time.

05) After through ventilation, tank atmosphere tested for any toxic or explosive gases, by invited chemist or with Davy's safety lamp before entering.

06) When the tank is gas free, the following LSA to be carried or kept ready, when entering,

- **a.** Lifeline or harness to be put on.
- **b.** Spark proof hand torch to be brought in.
- **c.** BA set to be kept ready.
- **d.** Resuscitation equipment to be kept ready.
- **e.** Have rescue team, readily available and properly led.
- **f.** Competent person, stand by at entrance.
- **g.** Agree a communication system, before entry.
- **h.** Have adequate illumination.

18. What precaution to be taken before enter the tank ?

1) Gas free certificate
2) Tank entry permit
3) Davy safety lamp to be brought into and test tank air
4) Breathing apparatus, resuscitation equipment to be kept ready at entrance.
5) Life line to be put on
6) A spark proof hand torch light to be brought in
7) competent person to be kept on watch
8) Smoking and naked light not allowed in vicinity

19. Is there any device onboard to detect any foul gas ?

Davy's safety lamp is employed for detection of tank atmosphere it is explosive gas or any foul gas such as CO_2.

20. How to extinguish E/R bilge fire ?

⇨ First check the condition of fire; it is small oil fire in the bilge well.
⇨ Then raise the fire alarm signal.
⇨ Remove the combustible material near vicinity
⇨ It is a small fire, extinguish by foam portable extinguisher. It is operated by releasing the cap the cap by means of operating handle and turning it up side down. Foam will emit from nozzle.
⇨ Release the foam direct to the fire by deflecting it from another surface.
⇨ Foam is lower specific gravity than oil or water that it will flows across the surface of oil and cover.
⇨ The fire will stop by blanking with foam.

21. What are the effects of chemical form ?

The extinguishing effect of the form is a combination of smothering and cooling.

When burning surface is covered with foam, it will insulate the flame from the liquid surface, there by the heat radiation against the liquid is decreased and the gas generation decreased. So that the fire stops.

Foam is used against fires in oil surface.

What is chemical foam safety device ? It function ?

1. Small radial hole at cap
2. Atmosphere valve

The cap has small holes in the threads or also has in the middle of bottle thread so that any internal pressure must be released before the cap is fully removed.

Firstly, unscrew slowly foam will emit, so it cannot injure.

22. What is fixed installation ?

It is a fixed fire extinguishing equipment fitted for engine room and C/H to extinguish the immerse fire controlled by remote station, (Eg. usually mechanical foam or CO_2.)

23. How do take action for cabin fire ?

- ⇨ When I found the fire in cabin give the alarm signal.
- ⇨ Check the condition of fire and remove the combustible material near vicinity.
- ⇨ Isolate electrical supply to that cabin.
- ⇨ Take the soda acid or CO_2 or foam portable extinguisher from the alley way.
- ⇨ If use soda acid type, remove the safety guard and strike the knob smartly.
- ⇨ Then release the water to the fire spaces.
- ⇨ Give the boundary cooling to it adjacent spaces, if the fire is great.
- ⇨ The fire will stop by cooling effect.

23. Safety devices on CO_2 fixed installation system ?

- ⇨ Master valve with alarm switch for cargo hold.
- ⇨ Relief valves at each brunch line
- ⇨ Stop valve and pull handle are in lock cabinet and alarm switch.
- ⇨ Safety bursting disc at each CO_2 bottle.

Maintenance of CO_2 flooding System

1. Before entry CO_2 room must be well ventilated
2. Weekly inspection for alarm system
3. Bottle should be weighted yearly, level checked by ultrasonic or radio active isotope detection. Level reference mark should be provided. If 10% loss of weight, recharge them.
4. All the pulley, wire, rope and toggle must be free from dirt, scales and well lubricated.
5. CO_2 branch pipe and nozzle should be cleared with compress air at two year interval
6. Bottle should not be exposed to temperature of 60°C

24. How will you do for cargo hold fire ?

- ⇨ Remote detector fitted at the bridge can detect concerned cargo space.
- ⇨ This operation must be done by master's order.
- ⇨ After ensuring no person left in cargo space, seal off the cargo space (closing of ventilation fan, fire damper, and hatch cover).

25. Where do you use CO_2 A fire extinguisher ?

- ⇨ CO2 fire extinguisher is used in electrical equipment fires.
- ⇨ It is electrically nonconductor.
- ⇨ CO2 is heavier than air but it can be carried away by combustion gases and flame, if it is used out door.
- ⇨ The best condition for extinguishing is in enclosed space.
- ⇨ CO2 is a clean medium and give no residue, therefore it has no secondary damages.

26. What point to be checked after cleaning the FO service tank ?

- ⇨ Check heating coils that is no deformation and burst.

- ⇨ Check bolts and bracket of heating coils and their tightness.
- ⇨ Check magnesium anode.
- ⇨ Check float ball indicator.
- ⇨ Check numerator tank gauge.
- ⇨ Check striker plate wear down.

27. How will you test smoke detector ?

Smoke test- by applying smoke to the detector head, alarm will activate and light up the indicator lamp.

Check the line cleanliness between cargo hold and smoke detector by checking nylon propellers. It must rotate when are clear.

Any blockage can be clear by using compressed air. (Open the 3-ways valve fully, it will contact the CO_2 main and cargo hold line and blow with compressed air.)

28. What is the fire control plan ?

It is a general arrangement plan which shall be permanently exhibited onboard for the guidance of ship personal and also exhibited outside the deck house with water tight enclosure for the guidance of shore fire brigade.

It consists of –

1) fire control stations
2) Location of various portable fir extinguisher & FFA.
3) Fire detecting and alarming system.
4) Means of escape.
5) Ventilation system.
6) Fixed fire fighting instillation system.

29. Principle of fire fighting ?

- ⇨ Cooling to reduce the temperature.
- ⇨ Smothering to reduce emission of vapour.
- ⇨ Cutting off combustion material.
- ⇨ Cutting off O2.
- ⇨ Interrupting chain reaction by chemical.

30. What is international shore connection ?

It is a standard size flange, together with bolts, nuts and washers which has a couplings fitted which is suitable for the ship's hoses. It is used to connect up the shore water main in any port to the ship's fire main and equipment. (w.pr –10.5 bar)

Material ➵ Steel at 1.0 N/mm2 designed

Dimension
- ➵ OD = 178 mm,
- ➵ ID = 64 mm,
- ➵ PCD = 132 mm,
- ➵ Flange thickness = 14.5 mm
- ➵ Slots in flange: 4 holes, 19 mm Φ, equal spacing
- ➵ Bolts & nuts: 4, 16 mmΦ , 50 mm length, 8 washers

31. Why fitted emergency fire pump on board ship ?

It is fitted and alternative means of providing water for fire fighting if a fire in any one compartment could put all the fire pumps out of action either by disabling the pumps of their source of power.

32. E/R fire fighting / detecting equipments.

- ☞ 2 no of fire hydrants at each floor.
- ☞ 3 types of portable extinguisher.(CO_2, foam, Dry powder) Located in easily accessible position (2 nos. of within 10 m) and correct type to deal with expected class of fire in that area
- ☞ Non-portable fire extinguisher (136 Litres (50 gallons) foam extinguisher for boiler space.)
- ☞ Sand box with shovel.
- ☞ Smoke detector and alarm system.
- ☞ Fixed instillation system.

Mechanical foam	Chemical foam
Bubble filled with air	Bubble filled with CO2
Foam produced by mechanically mixing of foam concentrate , water & air (Special nozzle require)	Foam produced chemical reaction of $Al_2(SO_4)_3$,$NaHCO_3$, & foam stabilizer
Expansion ratio is higher 30:1, 200:1	Lower expansion ratio
Mostly used fixed installation & non portable extinguisher	Mostly Used as PFE

CO_2 SYSTEM REQUIREMENTS

1) Engine room 40% of gross volume, (for < 2000 GRT cargo ship 35%)
2) Safeguard against unauthorized usage
3) Machinery sector valve fitted with alarm and blower trip
4) Operation triggers alarms
5) Permanent piping (up to bilge and tank top)
6) Distribution piping mover than 19 mm diameter
7) Distribution manifold and piping tested 122 bar
8) Copper pipes and high pressure flexible pipes allowed between cylinder outlet valve and manifold
9) Pipes to cargo space not to pass through E/R unless all pipes tested to 122 bar

Requirements of CO_2 Bottle	**CO_2 Properties Limitation**
1) All bottles stamped at 52 bar **2)** Bursting disc 177~ 193 bar at 63°C **3)** Store in temperature less than 55°C **4)** Recharge if 5 % loss **5)** Clamped against movement and vibration(by wooden plank) **6)** Remote and manual operation **7)** Hydraulically tested to 228 bar **8)** Level tested (by radio active level indication) **9)** (if > 10 years internal and external examination required	**01)** CO_2 is heavier than air **02)** Less cooling effect **03)** Static electricity induced **04)** Heavily asphyxiating (suffocating) **05)** Ineffective if > 10 ~ 12 minutes **06)** "One off" no reserve **07)** Total evacuation required **08)** Possibility of thermal shock **09)** No protection of personal **10)** Expands 450 times its volume in liquid to produce gas.
CO_2 Room Inspection	**CO_2 Survey**

1) Check emergency light and all other lights **2)** Check exhaust fan / ventilation **3)** Check all bottles overall condition, clamps, valves etc. **4)** Check operating wire condition **5)** Check CO_2 alarms **6)** Key should be in position **7)** Check the operating instructions **8)** Inspection to be removed in log book and Saturday safety routine book.	**1)** Check weight every 2 years **2)** Testing of cylinder at 228 bars **3)** Blow through the lines **4)** General ➧ Instructions ➧Key ➧Emergency lights ➧Ventilation ➧Alarms etc.

CO_2 Room Safety Arrangement

Exhaust fan, and suction duct

Provide at the bottom of the room. Any accumulated CO_2 from leakage at the bottom can be exhausted to atmosphere.

Cable operated safety valve

Fitted on the pilot cylinder discharge line. It prevents accidental discharge of CO_2 from quick release cylinder due to action of leakage gas from pilot cylinder.

Relief valves

Fitted on each discharge line from cylinders so that leakage gas can safely dispose to atmosphere

Check valve

Fitted on connection pipe between each cylinder discharge valve and manifold, so that leakage of one cylinder cannot effect other cylinder.

Bursting disc

Each bottle has a combined bursting disc, which will rupture spontaneously at a pressure of 177 bar at 63°C

Pressure gauge and pressure alarm in the mainfold

Precaution before CO_2 operation

1) All personnel to be evacuated and head counted
2) All remote valves to be closed (FO, DO and LO tanks valve)
3) Stop all fuel and lub oil pumps from remote operation
4) Stop all ventilation fans from remote operation
5) All openings, skylights, funnel flaps etc to be closed
6) Open control box to activate CO_2 alarm (warning to personal for CO_2 release)

Precaution after CO_2 operation

For a room where CO_2 has been released, take the following cautions without fail.

1) In CO_2 atmosphere, you are in danger of suffocation due to oxygen lack. Never attempt to enter into a room filled with CO_2 without putting on breathing apparatus. Before entering into the room full of CO_2 never fails to put on hose type or oxygen type breathing apparatus. But don't use activated carbon type mask.
2) The room should be ventilated after fire in the room has been extinguished completely, Enter into the room when it becomes full of fresh air.
3) Even after fire has been extinguished completely, never bring **bare flame** such as candle light or lighted cigarette into the burnt room, other wise fire may break out again due to explosion of combustible gases, if any.
4) In order to allow persons to get away quickly and safely in case of fire, entrances and exits shall be always kept clear in particular carefully at around CO_2 injecting sports.
5) Should a person be suffocated with CO_2, bring him into a place of fresh air without delay and practice artificial respiration. Some of the symptoms of suffocation are as follows:
   a) Accelerated respiration
   b) Accelerated pulsation
   c) Debility
6) When extinguishing fire from electrical equipment, turn off power as soon as possible for checking spread of fire and safety.

Safety device on life boat

Mechanical brake (to prevent accident falling)
Centrifugal brake (to control life boat falling speed between 20 to 40 m/min)
Limit switch (to prevent over tightening of rope) (it is fitted arm of davit just before in limit)
Harbour safety pin (for davit)

Windless safety device

Cable stopper (chain stopper, bow stopper)
Overload trip
Hand brake
Slipping clutch for overload prevents any undesirable damage such hull damage due to anchor and rope broke out.

How will you do for cargo hold fire ?

01) If cargo hold (C/H) fire broken out. While the ship is at sea.
02) Smoke detector will give alarm and signal on the bridge. Duty officer will check which cargo holds is broken out of fire.
03) Give the fire alarm
04) To extinguish the fire. Following procedure must be done
05) Check any person left in the cargo hold (Head count all crew). Totally isolate the cargo hold. (Shut cargo hold ventilation, blower and damper) hatch cover, man hold.
06) Fully open the three way valve to that cargo hold, the line to smoke detector is closed and connect the CO_2 main line and cargo hold.
07) Then I go to CO_2 room and open master valve for cargo hold.
08) CO2 alarm will sound in the cargo hold
09) Check the required amount of CO_2 bottle to use for that cargo hold.
10) Then release required CO_2 t cargo hold by pulling the wire connected to CO_2 to cargo hold by pulling the wire connected to CO_2 bottles or open one by one by manually
11) Fire will stop because room atmosphere is smothering by CO_2 gas.

Inert gas generator.

1. Special air cooled diesel generator.
2. Washing & cooling boiler flue gas.

Gas ~ N_2 85%, CO_2 14%, O_2 1%
Maintain 75 milli bar above the cargo.

Sprinkler (quartzoid bulb)

Red - 68' C
Yellow - 79'C
Green - 93'C
Blue - 141'C
Violet - 182' C

PUMP

Cavitations

Cavitation can be occurred when the pump suction contains air or when the pump is running faster than the designed speed.

Low pressure regions occur in the flow at points where high local velocities exist. If vaporisation occurs due to these low pressure areas then bubbles occur, these expand as they move with the flow and collapse when they reach a high pressure region.

Such formation and collapse of bubbles is very rapid and collapse near a surface can generate very high pressure hammer blows which results in pitting, noise, vibration, and fall off in the pump efficiency.

So the pump should be run at designed speed and throttling of the suction valve should be avoided.

How to no water come from ballast Pump ?

1) Incomplete priming
2) Too high suction lift
3) Low net positive head
4) Air leaks in suction line
5) Gas or air lock
6) Suction filter choke

Screw pump overhaul

1) Remove fuse from motor starter box
2) Close suction and discharge valve
3) Remove suction and discharge pipe flange bolt & nut, coupling bolt of motor coupling
4) Remove pump foundation bolts & take out pump from motor
5) Remove gland nut, take out gland & gland packing and neck bush
6) Remove cover both side & remove driver screw & driven screw with bearing.
7) Clean all parts.

Screw pump check point

- Neck bush surface condition
- Bearing
- Driver screw and driven screw wear & tear
- Pump casing internal surface
- Clearance between driver and driven
- Clearance between driven and casing
- Clearance between driver and casing.

Centrifugal pump overhaul

1) Remove fuse from motor starter box
2) Close suction and discharge valve
3) Remove suction and discharge pipe flange bolt & nut, coupling bolt of motor coupling
4) Remove pump foundation bolts & take out pump from motor
5) Remove impeller lock & nut & take out the impeller
6) Remove gland nut and take out gland, packing neck bush
7) Remove bearing cover from other side & take out shaft with ball bearing
8) Clean all parts.

Check point

Impeller → Wear ring →Neck bush → Ball bearing → shaft.

EXPLOSIONS

1. How will airline explosion occurred ?

The main cause of starting airline explosion is the leaking starting air valve or jamming at open position of the valve.

Initially, the oil which is discharged from the air compressor to starting air line system it will deposit as a thin moist film on the internal surface of the pipes but not ready to combustion.

If starting air valve leaked or jammed at open position, hot gas or flame may enter the starting air manifold, vaporize the oil and set the fire to oil mist and greasy matters, which generally deposit on the surface.

At that condition, *mostly arrival first start* for manoeuvring time, high pressure compressed air coming into contact with the fire and may cause explosion.

2. How to prevent the air line explosion ?

- ➔ Made regular overhaul and maintenance of starting air valve.
- ➔ Before departure, test the air starting valve leakage.
- ➔ Regular drain off the air bottle drain valve.
- ➔ Regular drain off air starting system.
- ➔ Regular cleaning of the compressor suction air fitter and used oil wetted suction fitter
- ➔ Feed minimum absolute cylinder lubrication to compressor.

3. Safety devices on starting air line ?

- ➔ Spring loaded safety valve or bursting cap.(if bursting cap fitted, no need relief valve)
- ➔ Flame trap.(At Joint where manifold to each cylinder starting line)
- ➔ Starting air line drain valve (Inlet of automatic valve)
- ➔ ~~Turning gear interlock~~
- ➔ ~~Reversing interlock~~

4. How to test starting air valve leakage ?

- ➔ By hand touch feeling to adjacent pipe to the valve while in engine is operating.
- ➔ If leak hotter than others

By means of pressure testing prior to the sailing. (In port)

- ➔ Shutting the isolating valve to air pilot distributor
- ➔ All indicator cocks must be opened
- ➔ *Disengage the turning gear*
- ➔ Open the main air bottle stop valve
- ➔ Set the control lever to starting position
- ➔ Check all the indicator cocks
- ➔ Escape of air through indicator cock will show a leaking starting valve
- ➔ It should be replaced immediately.

Safety cap

When explosion occurs burst out of safety tube, the outer hood can be moved round just far enough to blank off the holes in the inner hood, thus preventing air leaks when the engine continue using air. It is only use for emergency and the safety tube should be renewed as soon as possible.

The detector fixed to the safety cap will by bent out at the explosion and it tells at a glance which tube has busted.

Safety Cap maintenance

a By instruction, renewed or reusable.

a For renewable type, renew after complete running hours.

a For reusable type, annealing must be done.

5. What notice if scavenge fire occur ?

When fire has been broken out-

- The scavenge air and the exhaust gas temperature of particular cylinder will increase.
- In some causes turbocharger start may surging.
- The engine will slow down immediately because the cylinder will not be receiving their normal charge of fresh air at the end of the firing stoke.
- Heavy smoke will emit at exhaust funnel.
- Discharge of sparks, flame or smoke through drain cocks from scavenge air box.
- Cooling outlet temperature of the affected cylinder increases.
- Visible outlet temperature of the affected cylinder increases.

6. What is scavenge space fire ?

In scavenge air space there is normal accumulation of carbonized cylinder oil, unburnt fuel and carbon from the residual products of combustion. They will ignite under certain faulty operating condition (such as flame blow by) indicating afire in the enclosed scavenge air box. This is a scavenge fire.

7. How to prevent scavenge fire ?

- Keep piston rings in good working order.
- Find the adequate amount of cylinder oil
- Drain the scavenge space at every watch.
- Clean the scavenge space and exhaust port regularly
- Keep the fuel injector tight.
- Cylinder liner wear must be within admissible limit.
- Prolong engine or any cylinder over loading must be avoided.
- Piston rod stuffing box must be maintained to prevent oil ingress in the scavenge space.
- In case of times lubrication, the time has to be checked as per PMS.

8. Causes of scavenge space fire ?

The main causes of fouling of the scavenging air space are blow by of the products of incomplete combustion.

Factors contribute to the scavenge fire:

1) Blow past of combustion products caused by –
   - 1a) Leaky sticky or broken piston rings
   - 1b) Bodily worn out liner, scoring or scuffing at the liner surface.
   - 1c) Faulty cylinder lubrication (i.e. quantity, quality or timing)
   - 1d) Insufficient axial clearance of piston rings.

2) Overheated piston dissipates heat to the under piston area caused by -
   - 2a) Faulty atomization and injection pressure
   - 2b) Faulty fuel pump timing
   - 2c) Lack of scavenge air
   - 2d) Engine operation in overload condition
   - 2e) Failure of coolant circulation or insufficient cooling due to formation of scale.

3) Blow back of exhaust gasses by caused by –
   - 3a) Fouling of grid before turbine inlet
   - 3b) Fouling of turbine blades
   - 3c) Choking of EGE or economizer gas outlet
   - 3d) Partly chocked exhaust ports

4) Sometimes contain fuel oil due to-
   4a) Defective fuel injector
   4b) Incorrect pressure of injectors
   4c) Fuel particles landing on the cylinder liner.
5) Excessive cylinder lubrication which is drained to the scavenge spaces
6) Oxygen plentiful during engine operation
7) Fouled scavenge manifold.

- ☞ The accumulation of fuel residues mixed with excessive cylinder oil in the scavenge air space.
- ☞ Accumulation of such mixtures can be set alight by the sparks or flame blow by scavenge fire occur.

Causes of scavenge space fire ?

The main causes of fouling of the scavenging air space are blow by of the products of incomplete combustion. Due to –

- ☞ *Defective fuel injector*
- ☞ *Faulty fuel pump timing*
- ☞ *Lack of scavenge air*
- ☞ *Partly chocked exhaust ports*
- ☞ *Engine operation in overload condition*
- ☞ *Defective piston rings or*
- ☞ *Badly worn out cylinder liner.*
- ☞ *The accumulation of fuel residues mixed with excessive cylinder oil in the scavenge air space.*
- ☞ *Accumulation of such mixtures can be set alight by the sparks or flame blow by scavenge fire occur.*

9. Dealing to scavenge space fire ? **Action**

a) If the fire is not too great

- ⇨ Inform to the bridge to reduce the engine speed.
- ⇨ Reduce the engine speed
- ⇨ Cut off the fuel to concern cylinder
- ⇨ Increase the cylinder lubrication to that cylinder
- ⇨ Shut the scavenge drain valve.
- ⇨ Coolant flow through jacket and piston is maintained.
- ⇨ Keep clear of scavenge space relief door to prevent human injury.

b) If the fire is too great

- ➔ It necessary to stop the main engine, inform to the bridge and take the permission to stop.
- ➔ The turning gear should be engaged as soon as engine stopped and turn the engine. (To prevent overheat, distortion and seizer of the engine parts.
- ➔ If the fire fighting equipments is fitted, it should be brought into operation.
- ➔ If no equipment is available the fire will generally subside in about 5 to 15 minutes.
- ➔ Person should avoid standing close to the relief valve.

Fire should be extinguished after sometimes, If the fire spreads in the other scavenge spaces along with the scavenge manifold, then-

1) Inform bridge and stop engine
2) Stop fuel oil booster pump
3) Open indicator cocks, engage turning gear and turn engine to prevent engine seizure
4) Normal engine cooling and bearing lubrication are maintained
5) Scavenge air duct flap valve before engine is to be shut
6) Release the smothering gas (CO_2or steam) to extinguish fire
7) Before opening scavenge door ventilate the space thoroughly if CO2 is released.

10. Cleaning and inspection after extinguishing the fire ?

After extinguishing the fire the engine should be cooled down at least 15 minutes.

All the scavenge air space should be opened

Then thoroughly cleaned and all debris removed

After cleaning the piston rods and cylinder liner should be examined for surface blemishes and straightness.

Examine the diaphragm glands to ensure that they are operational and not damage.

Inspection After Scavenge Fire

1) Intense fire can cause distortion and may upset alignment.
2) Check by turning engine and watch movement of piston in liner, check for any occurrence of binding at part of stroke (Binding indicates misalignment of piston)
3) Check spring on scavenge space relief device, if the device was near the set of fire.
4) Piston rod packing spring also should be checked, which may have become weakened by overheating
5) Check piston rings and liner for any distortion or burning (reddish) mark
6) Check diaphragm and frame near affected part.
7) Check guides and guide shoes
8) Check tie bolts pretension.

Scavenge Space Protection Devices

1) **Electrical temperature sensing device** fitted within the trunking, which will automatically sound an alarm the event of an excessive rise in local temperature (above 200°C)
2) **Pressure relief valves** consisting of self-closing spring loaded valves are fitted and should be examined and tested periodically.
3) **Fixed fire extinguishing system** may be CO_2, Dry Powder or Steam.

11. What is crankcase explosion ?

An explosion occurs in the crankcase. For an explosion to occur there must be in the crankcase a mixture of oil mist and air in the ratio that is within the range of flammability.

In addition there must be a source of high temperature energy sufficient to initiate combustion. Explosion occurred. This source is called hot spot.

12. How to cause crankcase explosion ?

The normal content of crankcase is air. In this air there are oil globules (droplets) formed by the mechanical atomization of the oil as it s sprayed from the edge of the bearing and other places and as it is thrown about and churned by the quickly moving parts.

If a hot spot occurs the oil particles in the neighborhood will evaporate. This evaporation may cause the formation of a quantity of white condense oil mist in the cooler regions. The continual generation of heat at hot spot vaporization may proceed a space until the ratio of vapour to air lies within the range of flammability.

If hot spot can provide the necessary heat for ignition of vapour, a primary explosion may occur.

13. What is hot spot, and why occur ?

It is an overheated part, sufficient to initiate combustion.

A hot spot occur due to –

- ☞ Failure of lube oil to bearing, sprockets and similar parts.
- ☞ Hot gas blowing past the pistons may provide spark sufficient to cause an explosion in the trunk type pistons engine.

(Hot spot temp: 280-400 °C Above the L.O flash point)

How will you know whether hot spot or not ?

1. By hand feel to crankcase door
2. Abnormal noise in crankcase. Irregular running engine
3. Bearing L.O temperature increase
4. Alarm will operate when it reach at oil mist concentration 2.5 – 5% LEL
5. Smelling & appearance of the dense oil mist when open breather pipe, drain cock.

14. How to prevent the crankcase explosion ?

- ☞ To minimize the formation of explosive mixture.
- ☞ Breather pipe ~~or exhaust fan~~ fitted on crankcase.
- ☞ To prevent the formation of hot spot in the crankcase.
  - **a.** The bearing should be in correct running clearance.
  - **b.** Lubricating oil should be adequately supplied to bearing , chain with sprocket wheels and other running parts
  - **c.** The piston with rings and cylinders should be in safe working limits.
  - **d.** Good fitting and efficient locking of working parts.

Preventive measure of crankcase explosion

01. Engine cooling should be continued for sometime to ensure adequate cooling of the engine.
02. Engine proper purification and analysis of lub oil.
03. Lub oil filter to be changed over & cleaned as per schedule
04. Ensure proper cylinder lubrication by checking the condition of piston, piston rings and liner through scavenge or exhaust ports
05. Clean scavenge space as per schedule & drain scavenges space regularly.
06. Maintain the stuffing box gland sealing in good condition
07. All running gears maintenance & checks to be carried out as per PMS
08. Be alert & rectify for any abnormal noise in crankcase
09. All safety trips & alarms fitted on M/E to be tried out for satisfactory
10. Proper watch on al running gears temperature & pressure to be maintained
11. Blow through all sampling tubes of OMD regularly
12. Zero adjustment & sensitivity of OMD to be checked regularly
13. Check for oil leakage at crankcase explosion relief doors & check for the operation by hand
14. Check flame trap for cleanliness and intact condition.

Action after detecting hot spot

01. Inform C/E & Bridge
02. Reduce the engine speed to reduce the heat generation
03. Increase lubrication to the running surfaces
04. Keep clear off crankcase relief door to prevent personnel injury, keep fire extinguisher ready 7 open skylight.
05. Inform bridge, stop engine, open indicator cocks, engage turning gear and turn engine with lub oil circulation continuing to prevent engine seizure.

06. After about 30 minutes or more when the engine is sufficiently cooled down , stop lub oil pumps and open crankcase door.
07. Try to locate the hot spot by hand feeling over and by observation
08. If the hot spot is located, prevent reoccurrence by making permanent repair
09. Make through inspection of crankcase.
10. Pay particular attention to hot bearings, piston, bottom end bolts, guides and piston rod around stuffing box.
11. Start lube oil pumps and check for proper flow of oil from every lubrication point.
12. If everything is found normal, inform bridge, start the engine and gradually increase speed. Outside feel over sequence to be carried out for satisfactory operation.

15. Crankcase safety devices ?

1) Breather pipe with flame trip ~~**2)** Exhaust fan~~ **3)** Oil mist detector **4)** Crankcase relief doors. **5)** Bearing temperature sensor **6)** L.O return temperature sensor **7)** Routine test on used L.O for viscosity, flash point and contamination.

16. Why is breather pipe fitted in the crankcase ?

It is fitted to prevent crankcase explosion and to reduce pressure build up in it.

It maintains the pressure level in the crankcase about 25mm of water below the atmospheric pressure.

Why crank case relief valve is fitted ?

It is fitted to release any sudden rise of internal pressure with large free escape area thus to prevent secondary explosion

17. Requirements of crankcase relief valves ?

The internal combustion engine of a cylinder diameter of 200 mm or a crankcase volume of 0.6 m^3 and above shall be provide with crankcase relief vale of a suitable type with sufficient relief area.

In small engine cyl: dia; does not more than 300mm, crankcase door of which are usually very strong. It may have relief valve or valves at its end.

In large engine, cyl: dia; over 30cm, It required one relief valve to be placed on each crankcase door.

Its free area should not smaller than 45$cm^2$and there shall be minimum of 115$cm^2/m^3$of the gross crankcase volume.

Spring setting for opening pressure is 0.07 bar at an internal pressure and will close when the pressure has been relieved.

The valves open smartly and close positively and rapidly.

18. How would you test crankcase relief valve ?

When engine is stopping, after removing the flame trap and press up the valve disc and check the action of opening and closing.

The valve must be opened smartly and closed positively and rapidly. The valve must be oil and gas tight.

When the engine is running we must only check the oil leakage that the v/v is seal or not.

19. Causes of bearing high temperature ?

- ☞ Improper viscosity of oil
- ☞ Insufficient lubrication
- ☞ Misalignment of shaft or bearings
- ☞ Foreign matters in oil
- ☞ Score journal
- ☞ Poorly fitted bearing
- ☞ Improper oil clearance
- ☞ Whenever the bearing begins to heat up, check the lubrication whether it is clear, correct temp: and flow sufficient or not.

20. What is the blow pass /blow by ?

Blow pass and blow by is the same. Hot gas or flame passed through the piston rings and cylinder liner from the combustion space.

21. What are EGE fire/ Why EGE fire occur?

- ⇨ A flame is appear at the economizer coil during running of main engine at sea while the EGE is put into service with circulation water passing through the coils it is called economizer fire.
- ⇨ It is actually cause by soot fire at the economizer coils.
- ⇨ For the economizer coils fire, heat is already presented due to passing the gases of ME .
- ⇨ Air due to excess supply of scavenging air into the unit combustion chamber.
- ⇨ Fuel is thick deposit ,unburnt fuel, carbon residue (soots) sticking at the economizer coils .
- ⇨ Soots are formed from incomplete combustion and use of low great fuel and high carbon content fuel.
- ⇨ At the manoeuvring time, the more incomplete combustion may occur and at that time leaving flue gas velocity is very low, thus unburnt fuel can be adhering on the economizer coils.
- ⇨ A flame is produced when air and fuel are proportionally mixed in the sufficient heating temperature.

22. Indication of EGE fire ?

- 👁 Smoke smell will get from the economizer.
- 👁 Over heat at economizer body (external casing of uptake.)
- 👁 Heavy smoke and sparks will emit from the funnel.
- 👁 Sudden unexpected increase in uptake gas temperature (Abnormally high stack pyrometer reading)
- 👁 Flame visible in the smoke indicator.
- 👁 Sparks emitted from funnel.

23. How to prevent it ?

- ☑ To get complete combustion. Maintain the M.E optimum combustion condition..(governor, fuel injection pump, fuel injection valve, fuel injection timing, fuel condition, air cooler, turbocharger, do not run too long M.E with slow speed)
- ☑ Regular open up & cleaning smoke side depending upon soot accumulation.
- ☑ Regular soot blowing operation. Check & maintain soot blowing equipment.
- ☑ Regular overhaul boiler burner, correct air fuel ratio & damper.

24. Dealing to economizer fire ?

- Inform to the bridge and CE. Take the permission to stop.
- Gradually slowdown the ME and then stop.
- If fire fighting equipment is fitted, it should be brought into operation.
- Cool down the economizer by means of boundary cooling
- Circulation pump must be run but large amount of water lost it must be stopped.
- There is no heat source and fire is out.
- When economizer fire occurs never made soot blow to economizer.
- It can cause hydrogen fire and melt down the coils stack. It can cause deformation and tube bulking because intensive heat and high thermal stress formed at economizer coils.

After fire is out

- Cool down to ambient temperature.
- Open the economizer cover.
- Clean inside parts of the economizer.
- Check the any defective coil and repair for temporary used by welding or plugging the tubes.

Fighting the fire

1) Slow down the engine.
2) Shut off oil burners, draught fans, dampers & air register.
3) Raise water level full and blow down continuously so as to maintain good flow of water.
4) Reduce boiler pressure by easing gear.
5) Spray water on the external casing of the uptake to cool the affected area.
6) A few times starting and stopping of M/E should be done to blow out collected soots at the uptake.

Big considerable soot fire

1) Shut down the engine.
2) Shut down the boiler.
3) Follow all of the above steps.
4) After the self perpetuating fire died down, open up & clean the smoke side with pressure jetting, check damage.

Self-perpetuating Fire (or) Hydrogen Fire.

When the fire causes the metal itself burning at about 700(C, if steam smothering soot blowing system or water jetting system have been attempted, the big hydrogen fire may result.

The applied steam dissociates into Hydrogen and oxygen and accelerating the fire.

Once such a fire has started, resulting two kind of fires may take place simultaneously, one kind, iron burning in steam, and the other, the hydrogen burning in an air exothermic way.

This combined fire being self supporting and lasting until the supply of steam is exhausted.

The primary object of dealing the fire is to cool the surface and burning material as quickly as possible.

25. Source of oil coming into air bottle ?

It is due to

- ⇨ Excessive oil level of compressor
- ⇨ Excessive cylinder lubrication
- ⇨ Defective oil scraper rings
- ⇨ Oil vapours inhaled from the engine room atmosphere.

26. What point to be checked when crankcase inspection ?

-To check

- Appearance of all parts inside the crankcase
  → Hot spot, → Corrosion, → Wear and tear
- Locking arrangement
- Loosing attachment
- Bolts tightness
- Chain inspection
- Lube oil system
- Metal chip in the crankcase
- Bearing axial play
- Crankcase relief valves, flame trap
- Crankcase door joints.
- Crankshaft deflection

27. Why fitted oil mist detector ?

- It is fitted to detect the oil mist concentration in the crankcase and to give early warning.
- To prevent the primary explosion.
- Alarm setting 2.5% of the lower flammable limit.

28. Oil mist detector maintenance ?

- Daily check zero adjusting (rajyme) (Send to shore)
- Daily check alarm system
- Clean measuring tube & reference tube
- Clean / wash mirror, lens and photo electric cells
- Adjust the mirror
- Check the lamp
- Check the blower fan efficiency
- Check rotating selector v/v performance
- Clean sampling pipes.

29. How will you take action when OMD alarm is on ?

- Inform to C/E
- Inform to bridge, take the permission to stop the engine
- Gradually reduce the engine and then stop.
- Cool down the engine.
- Check the inside parts of the crankcase inspection.
- Made necessary repaired.
- Reset O.M.D and start engine

Actions after receiving alarm from OMD

Note the position of the crankcase chamber having hot spot pointed by the sampling knob.
Operate the selector button; turn the sampling valve knob to zero position or zero check, alarm should stop.
Operate the check button the meter should swing on the scale and alarm should sound / operate
Release the selector button, if the alarm comes from the same crankcase channel then it is confirmed that the alarm is not false.

ELECTRO-TECHNOLOGY

What is emergency generator ?

- ⇨ It is a small separate generator which supplies the electric power for emergency load in the event of main power supply failure.
- ⇨ It is located outside the main and auxiliary machinery space and not forward of the collusion bulkhead.
- ⇨ It has own switchboard near vicinity.
- ⇨ It is provided with independent means of automatically starting,(by air or battery) to ensure immediate run up following a main power failure and repeated starts of at least 3 times, and further attempt can be made within the 30 minutes temporary battery life
- ⇨ Adequate and independent supply of fuel with a flash point of not less than 43°C (109.4°F)
- ⇨ Must be able to be started in cold condition up to 0°C (32°F)
- ⇨ For cold weather, JCW system must be treated with anti-freeze agent, and heating arrangement provided.

Emergency generator Maintenance

01) Every Saturday, emergency generator must be tested run
02) Air bottle pressed up or starter battery fully charged, at all-time
03) Changeover the selector switch to local position before starting
04) Make sure breaker switch at 'off' position before starting (an interlock between ER Main switchboard breaker and emergency switchboard breaker is provided to prevent simultaneous closure of both breaker)
05) During testing, check frequency, voltage and ampere
06) Fuel tank, always checked to ensure adequate level
07) Air filter of generator, regularly cleaned
08) Required tools and spares kept in a container
09) Emergency light for this room should be always checked

What is emergency switch board ?

It is a switchboard which distributes to emergency load that power is supply from emergency generator when the main power source failure.

It has two sections- one for 440V and another is 220V.

Emergency switch board distribution

1) There are 2 sections: 440 V and 220 V
2) Under normal condition, 440 V supply is taken from ER Main Switchboard, through a Circuit Breaker
3) When main power is lost, this Circuit breaker is tripped (opened)
4) Emergency generator comes into action, and supplies power through another circuit breaker
5) An interlock is provided, to prevent simultaneous closing of both breaker (both main and emergency generator may be running, simultaneously)
6) From 440 V section

a. Emergency Bilge pump
b. Sprinkler system
c. One of tow steering gears

7) From 220 V section
a. Navigation Equipment
b. Radio Communication
c. Transformed and rectified supply to Battery systems.

Transitional Emergency Power Battery (Emergency lights for 30 minutes)
Low power DC system Battery (Alarms and control system)

Various load supply from emergency generator ? **(Essential Services from Emergency Power Source)**

It is called emergency load

- Emergency lightening to alley way /boat deck / engine room.
- Navigation system
- Steering gear
- Emergency fire pump
- Emergency air compressor
- Battery charging
- Fire detecting and alarming system
- Radio equipments (Communication equipment)
- Daylight signaling lamp and ship's whistle
- Navigation Aids
- General Alarm
- Manual fire alarm
- Watertight doors

Emergency Power Sources

- All passenger and cargo vessels shall be provided with emergency sources of electrical power, for essential services under emergency conditions.
- Emergency source may be generator or batteries, but must be complied with the rules
- Emergency sources must be installed in position such that they are unlikely to be damaged or affected by any incident, which has caused to main power.
- Emergency source of power should be capable of operating with a list or up to 22 ½ ° and a trim of up to 10 °.
- Emergency generator with its switchboard, is located n a compartment which is
  - Outside and away from main and auxiliary machinery space
  - Above the uppermost continuous deck, and
  - Not forward of collision bulkhead
- Batteries: the above same rules applied, nut must not be fitted in the same place as emergency switchboard

Rules for Emergency Power Sources

Passenger ship

- Emergency generator shall be automatically started and connected within 45 sec
- Capable of supplying simultaneously at least the following services for the period of 36 hours

1) Emergency lightening (at alley way, stairways and exits, muster and embarkation stations, machinery space, control room, main and emergency switchboard, firemen's outfits storage positions, steering ger room,)
2) Fire detecting and alarming system
3) Internal communication equipments
4) Daylight signaling lamp and ship's whistle
5) Navigation equipment
6) Navigation lights
7) Radio installations, (VHF, MF, MF/HF)
8) Watertight doors
9) One of the fire pumps, emergency bilge pump

- A set of automatically connected Emergency batteries must be capable of carrying certain essential services for the period of 30 min.

1) Emergency lighting
2) Navigation lights
3) Fire detecting and alarming system
4) Internal communication equipments
5) Daylight signaling lamp and ship's whistle

Cargo Ship

- Emergency power source, Emergency generator must be sufficient to operate certain essential services at least for the period of **18 hours**.

1) Emergency lightening (at alley way, stairways and exits, muster and embarkation stations, machinery space, control room, main and emergency switchboard, firemen's outfits storage positions, steering ger room,)
2) Fire detecting and alarming system
3) Internal communication equipments
4) Daylight signaling lamp and ship's whistle
5) Navigation equipment
6) Navigation lights
7) Radio installations, (VHF, MF, MF/HF)
8) One of the fire pumps, emergency bilge pump

- Where emergency source of electrical power is an accumulator battery, it shall be capable of carrying loads without recharging and battery voltage throughout discharge period must be maintained within 12% above or below its nominal voltage
- Battery system is automatically connected upon loss of main power
- Batteries are required as transitional power source for **30 min** for following items

1) Fire detecting and fire alarm
2) Emergency lightening
3) Navigation lights
4) Internal communication equipments

Emergency generator Starting when black out

1) Normally cut in automatically when main power fails
2) Starting is initiated by start up relay

3) Falling of frequency or voltage of Main power, cause the start up relay to operate generator starting equipment

4) If this system fails, after switching the MODE selector to Manual (Local) position, generator can be started manually by means of Back up starting equipment within 30 minutes of transitional emergency power battery lighting

Emergency light Maintenance

- Every Saturday, routine testing of emergency lights, carried out by E/E
- Ensure that batteries are fully charged and ready for use
- Burnt out bulbs replaced at once

Emergency lighting

1) Engine room lighting
2) Bridge lighting
3) Passage way lighting
4) Embarkation light

Requirements for Navigation Light panel

- Navigation light should be connected to a distribution board, which does not supply other services
- There should be a changeover switch, so that it can be transferred to another source or power supply
- Visual and audible alarms required for individual Navigation Light failure (duel bulb system for change over)
- Fuse protection provided

Navigation Lights

1) Fore Mast (No. 1 & 2 or Up, Down)
2) Main or Aft Mast (No. 1 & 2 or Up, Down)
3) Stern light (No. 1 & 2 or Up, Down)
4) Part light (No. 1 & 2 or Up, Down)
5) Starboard light (No. 1 & 2 or Up, Down)

What is shaft generator ? Advantages and Disadvantages ?

It is an alternator driven by main propulsion unit through clutch and gearing to produce electricity.

It can be used while vessel at sea running with a sea speed.

It must be able to supply normal sea load.

Advantages

- Slightly reduce total fuel consumption.
- Reduced running hours of auxiliary generator.
- Reduced noise in E/R.
- Can made overhauling the aux: G/E at sea.

Disadvantages

- Can not be used at rough sea.

- Increase load on main engine
- More complicated mechanism.

What is earthling device ?

It is a propeller shaft grounding device. Its function is to ground the static electricity to the ship hull caused by propeller rotation.

What is earth lamp ? How will you know when earth fault occur and how to trace it ?

A set of lamps, which show the presence of earth fault in distribution system. Each lamp is connected between one phase and common neutral point.

If earth fault occurs the lamp will show dim light or goes out because potential is zero.

The location of fault can be traced by switching off the individual branch circuit breaker and checked the condition of earth lamp. When the branch circuit with the fault is switched off, the earth lamp will return to normal brightness.

Earth lamps of 3 phase, 3 wire system, AC

- Each lamp is connected to secondary connections of each single phase step-down transformer, and primary connections are common to star point, which is earthed to ship structure.
- Normally 3 earth lamps burn with equal brightness if there is not fault
- If phase A is earth fault, lamp A becomes dark while the other two lamps burn with extra brightness
- Location of fault can be traced, by switching off the branch circuit, one at a time
- When branch circuit with fault is switched off, dark lamp will become normal glow and all 3 lamps burn with equal brightness.

Why earth lamp is fitted ?

Earth lamp is fitted to give visual signal when there is an earth fault occurs in the system.

What is megger insulation test ?

The instrument used for measuring high resistance in million of ohms. It is used for measuring the insulation resistance of cables, electrical equipments wiring insulation.

Why Megger Reading is taken ?

- To verify insulation resistance
- To detect insulation fault

Megger testing

- Megger tester [generally a 500V set] is used for measuring high resistance, like insulation resistance of cable, electrical equipment and wire installation in million ohms
- The test voltage is produce either by an internal hand driven generator or by a battery and electronic voltage changer.
- A measurement of the insulation resistance gives one of the best guides to the state of health of electrical equipment.
- The resistance should be measured between insulated conductors and earth, and between conductors.

- To get more accurate results, using the large instrument, it is important that the terminal marked earth, which is the + ve pole, shall be connected to the earth

AC	**DC**
Phase to phase	Pole to pole
Phase to earth	Each pole to earth
Rotor winding to earth	Field to earth
	Armature to earth

How insulation Resistance of a motor is tested ?

1) Switch off at Main switchboard
2) Take out the fuse
3) Tag the label on the S/B Don't start
4) Disconnect the connection from starter
5) Test with megger
6) Insulation Resistance is tested while at hot condition because it is minimum at that time

Difference between earthed and short circuit ?

Earthed

A fault in an electric circuit where a conductor come into contact with the ship hull or a met enclosure. (leakage of conductor due to insulation failure to ground.)

Short circuit

A fault condition where a low resistance connection occurs between two points in a circuit, a large current flow will usually occurs. (contact to each other or leakage of line conductor or leakage of line to neutral.)

Switchboard safety devices ?

- Overload trip
- Preferential trip
- Under voltage trip
- Over voltage trip
- Reverse power relay (No voltage trip)
- Reverse current trip
- Fuse
- A .C .B(Air circuit breaker)
- Earth lamps.
- Low frequency trip
- Meters
- Synchroscope
- Emergency synchronizing lamp
- Ebonite handrail and Rubber footstep

Precaution on Switch board

- An insulation rubber or plastic mat is placed in front of the S.B
- All metal parts of the S.B are connected to the earth
- The operator is to put on the electrician hand gloves to operate the switches

Switch board survey.

1. Performed during dry-docking. (G.E black out)
2. Check volt meter, ammeter, watt meter all calibrators and accuracy.
3. Check all trips over current trip, reverse power trip, preferential trip.
4. Synchronizing test. (load sharing test)
5. Switch inside each terminal to be checked for insulation resistance min: 1M , all contact must be clean.
6. Tightness of loose joint and connection, bus bar support, fuse holder.
7. Check automatic circuit breaker A.C.V and automatic voltage regulator A.V.R.
8. Earth detecting lamp and alarm system.

Meters fitted on main switchboard ?

⇨ Ammeter, Voltmeter, Wattmeter, Frequency meter, Ohm meter, Synchroscope.

What is essential load ?

Essential services those are required for the safety of personal and for the safe navigation and propulsion of the ship. They include certain supplies to navigation aids, machinery spaces, control stations and steering gear.

What is non-essential load ?

It is a load that has no effects on the safe navigation and main propulsion unit when they are cut off. They are

- ⇨ Air condition, some blower fan except E/R blowers, galley (1st trip 5 sec)
- ⇨ Refrigerated cargo plant (2nd trip 10 sec)
- ⇨ Deck equipment, purifier, air compressor, cabin power source except lighting (3rd trip 15 sec)

What is dash pot, where fitted ?

It is a mechanical device which makes time leg of trip with different viscosity of oil.

It is fitted –a overload trip

Preferential trip

Under voltage release / trip

Dash pot

- ⇨ Dashpots are fitted for overload trip to get time delay action, so that breaker will not be opened, due to momentary current surge
- ⇨ When load current is in excess, it attracts plunger of the solenoid
- ⇨ Plunger or piston moves up against the displacement of viscose oil or silicone fluid, through a small hole on the piston
- ⇨ Time lag depends upon hole size, and viscosity of oil
- ⇨ Load current setting for trip is about 25% above maximum, but should not exceed 50%

What is preferential trip ?

It is a generator protection device which is designed to disconnect nonessential load from the main switchboard in the event of generator over load or partial failure of the supply.

Preferential trip

1. Operate after a fixed time delay, causing non-essential loads to be shed
2. Usual setting for overload trip is 150% load (50% overload)
3. When generator load reaches 110%, preferential Trip comes into operation as follows
   First tripping at 5 sec

Shut down non-essential loads (air-condition, entertainment, accommodation fans, cargo hold fans, amplifiers, etc.) to reduce the generator load

Second tripping at 10 sec

Shut down essential loads (service required for running the ship properly, leaving the loads of top priority services to maintain propulsion and Navigation) if generator load is still high

Third tripping at 15 sec

Shut down the main generator as last action, if the load is still too high, it may be due to short circuit or insulation breaking.

Purpose of reverse power relay ?

If prime mover failure occurred, the generator would act as a motor; the reverse power relay detects this fault and acts to trip the generator circuit breaker.

What is fuse ?

Fuse is a protecting device it the circuit against damage from excessive current.

It is fitted in a circuit to protect the circuit from short circuit and over load.

Difference between Circuit Breaker and Fuse

Circuit breaker

1) Has switching actions to close the circuit or to open the circuit, and has a trip circuit if load current exceeds the set value

2) After tripping, circuit breaker can be reused without replacing any part

Fuse

1) Have only breaking function, and fitted in the circuit to protect the circuit from damaging effect of high current flow

2) It breaks the circuit by melting the fuse metal itself

3) After breaking, the blown fuse must be renewed

Intrinsically Safe

1) An electrical circuit or part of a circuit is intrinsically safe, if any spark or thermal effect produced normally (e.g. by breaking or closing the circuit) or accidentally (e.g. by short circuit or earth fault), is incapable of igniting a prescribed gas mixture, under prescribed test condition

2) An equipment, which cannot released sufficient electrical or thermal energy, under any condition to ignite a particular flammable vapour in its vicinity.

What is primary cells ?

It is a chemical cell in which it is possible to transform chemical energy into electrical energy .It can not recharge.

The internal resistance of a primary cell is usually high capacity of cell low and voltage per cell is also low. Simple cell consists of cu plate (positive plate) and zinc plate (negative electrode) and dilute H2 SO4 acid contained in.

What is secondary cell ?

It is a chemical cell (accumulator) which store up electric energy converting chemical substance into another form while charging. The store electric charge in chemical form transforms back electrical energy.

It has two types [lead acid and alkaline (Nickel Cadmium battery) type]. It has low internal resistance. Capacity and voltage per cell is high.

Nickel Cadmium battery [alkaline battery]

- + ve plate Nickel hydroxide + graphite
- - ve plate Cadmium + Iron
- ElectrolytePotasssium hydroxide solution (strong alkaline)
  - Normal Sp.Gr [1.21] does not change with charging or recharging
  - But Sp.Gr of Electrolyte gradually decrease, and Electrolyte should be renewed when Sp.Gr. becomes [1.160]
- It is a sealed battery, thus no gassing during charging
- Very low open circuit losses, but requires 67% more cells than Lead Acid battery [1.2 V per cell when fully charged 1.7 V per cell]
- Not harmful when overcharged
- Left for long period, either fully charged or fully discharged, without deterioration
- Better mechanical strength and durability than lead acid battery
- High initial cost but longer life

Lead Acid Battery

- + ve plate Lead Peroxide [chocolate brown]
- ve plate Spongy Lead [slate gray colour]
- Electrolyte fully charged H_2SO_4, SG 1.8, Renew when SG is 1.110. [1.8 V per cell when fully charged 2 V per cell] when undercharge, + ve plates are pale brown or yellowish, instead of deep chocolate and very difficult to convert back to normal form
- Efficiency (watt hour efficiency) is higher than Alkaline Cells

Battery room inspection and maintenance

1) Battery installation and its charging rectifier checked
2) Battery room environment must be dry and well ventilated
3) Battery tops shall be clean and dry, and terminal nuts must be tight and a smear of petroleum jelly applied to prevent corrosion
4) Electrolyte at proper level, and shall have correct value of specific gravity by checking with a hydrometer
5) Rubber gloves and goggles used when handling electrolyte
6) Charging equipment checked for dirt, overheating, loose connection and correct functioning of indicators
7) Ventilation arrangement for battery locker checked. Battery installation f both lead acid and alkaline needs good ventilation
8) Since both type generates hydrogen gas during charging, no smoking and naked light allowed
9) Steel works and decks adjacent to lead acid battery, should be painted with acid proof paint [For Cad-Ni cell, alkaline resistance paints]

Battery room safety arrangement

Safety is provided by

1) Proper ventilation
2) Prevention of heat source for ignition

Ventilation

- ⇨ Independent exhaust fan provided
- ⇨ Inlet duct should be below battery level, and outlet at top of the compartment

Prevention of heat source for ignition

- ⇨ No naked light and no smoking
- ⇨ Uses of externally fitted light or flameproof light
- ⇨ Cables of adequate size and they are well connected
- ⇨ Never placed Emergency Switchboard in this room
- ⇨ Use insulated spanner and plastic jug for distilled water, to prevent short circuit
- ⇨ Room temperature, maintained at 15 ~ 25°C

How do you know when the battery is full charge ?

- ☞ It can be known by measuring the electrolyte specific gravity by using hydrometer.
- ☞ If fully charge it has an specific S.G of about (1.27 – 1.285) Hydrometer scale 1270 to 1285
- ☞ If fully discharge which fall to S.G of 1.1 (1100) @ fully charged battery will warm up

How can you know battery is over charge ? Effect of overcharge ?

For battery is overcharged bubbles will form at the surface, the current flowing into the cell causes breakdown or electrolysis of water in the electrolyte.

Both hydrogen and oxygen are evolved and released through cell vent caps into the battery compartment. There is an explosion risk if H_2 is allowed to accumulate. (4% of H_2 in air).

When Battery is overcharged (Lead Acid battery) *Same as above*

- ⇨ Overheating cause buckling of plates
- ⇨ Internal short circuit
- ⇨ Sludge formed at the bottom of cells (lead peroxide)
- ⇨ Battery may be ruined
- ⇨ Lower the capacity

When Battery is undercharged (Lead Acid battery)

- ⇨ Over discharging
- ⇨ + ve plates are pale brown or yellowish, instead of deep chocolate
- ⇨ - ve plates, almost white colour
- ⇨ Falling of voltage 1.8 V / cell, and SG of H_2SO_4 1.15

Depolarisation

Liberation of H+ at – ve electrode (cathode) and that will decrease the current flow

Why AC is popular onboard ship ?

1) Smaller, lighter and compact machine size, for a given kW
2) High power and high voltage AC generator can be easily manufactured
3) Voltage can be raised or lowered by transformer
4) AC can be easily converted to DC

Electrical repair job hazard Electric shock prevention

1) Switch off the main switch
2) Out mechanical lock on
3) Take out fuse
4) Put a signboard “Man Working on Line”

A.V.R Automatic Voltage Regulators are used in conjunction with generator for controlling the terminal voltage to give a steady voltage under varying load

Types of A.V. R ?

- ⇨ Carbon pile regulator
- ⇨ Vibrating contact regulator
- ⇨ Static A.V. R.
- ⇨ Rotating sector
- ⇨ Multi contact
- ⇨ Magnetic amplifier
- ⇨ Electronic amplifier

Automatic voltage regulator ?

Which senses and controls an A.C generator’s output voltage within (+ or -) 1 to 2%.

Carbon Pile Regulator (AVR)

1) A resistance from a carbon pile (stack), which is varied by pressure changes, controls the current flow through exciter shunt field
2) Pressure is applied by springs and relieved by magnetic field strength of electromagnetic coil
3) Current for electromagnetic coil is supplied from Alternator output to switchboard
4) AVR is designed such that variations in Alternator Voltage, due to load change will effect strength of electromagnetic coil and hence alters carbon pile resistance
5) When Alternator voltage is low, spring exerts greater pressure and carbon pile resistance becomes low, so more currents flow through exciter shunt field and then increase the output voltage
6) When Alternator voltage is high electromagnetic coil relieves pressure on carbon pile and resistance becomes high. Less current flows through exciter shunt field and decreases the voltage

※ (Strength of Electromagnetic coil relieves spring pressure on carbon pile)

What is rectifier ?

It is an electric device or circuit capable to allow an A.C current to be converted to D.C current.

What is excitation ?

- ❖ To supply and control the correct D.C current for the rotor pole winding to produce the required generator A.C output voltages.
- ❖ Production of an electromagnetic field of a generator by supplying exciting current for magnetizing the field magnet
- ❖ For excitation, DC is sued because DC produces constant rate of magnetic flux

- ❖ Continually regulated to maintain the generator output voltages as the load demand fluctuates.

Exciters The source, which generates the field current for excitation of field magnets.

Equalizing bar

- ❖ Equaliser is a low resistance circuit, connected across armature ends of series coils of parallel compound generators, via a special bar in switchboard
- ❖ Equaliser is fitted to stabilize parallel operation of compound Dc generators.

Rotary converter

1) A rotating diode to convert AC to DC current for alternator excitation
2) Synchronous motor and generator combined unit
3) Filed and armature coils are similar to DC generator, except that slip rings are located on the end of the shaft opposite to commutator
4) AC turns the converter (as synchronous motor) and DC is taken from commutator brush

Procedure for alternator overhaul ?

- ⇨ Shut down the generator prime mover and lock off the starting system.
- ⇨ Lock off the circuit breaker and isolated the alternator electric heater. Tag the label on the switchboard.
- ⇨ Inspect the tightness of terminal connection and insulation.
- ⇨ Check the bearing oil level and condition.
- ⇨ Clean the cooling air intake filter and exhaust opening.
- ⇨ Clean the rotor and stator windings by means of vacuum cleaner with rubber hose and nozzle.
- ⇨ If the oil is deposited on the surface of winding, open the drain plug and then removed by special degresant liquids. (Electro cleaner)
- ⇨ Measure the air gap clearance between rotor and stator. (Carefully at lower part)
- ⇨ Baking the alternator with lamp. Keep a temp not more than 43 °C.
- ⇨ Disconnect the neutral point from the terminal box.
- ⇨ Measure between – rotor to earth
    - phase to earth
    - stator to earth
    - phase to phase
- ⇨ It is must at least one mega-ohm, if mega reading has reasonable value, the windings are to be covered with high quality air drying insulation varnish.

After maintenance work-

- ⇨ Reassemble all necessary parts.
- ⇨ Check no load running, the synchronizing and loading.
- ⇨ On load, practically check for excessive temperature rises and load sharing stability when running in parallel.

What is synchroscope ?

- ⇨ An instrument fitted at the main switchboard which indicates when two electrical supplies are in synchronism and can be parallel (or)

- ⇨ An instrument, which indicates that, voltages, frequencies and phase angle of two electrical supplies of running machine and incoming machine, are in synchronism and can be paralleled.
- ⇨ Synchroscope should not be left in circuit for more than 20 minutes as it cannot continuously rotate.

Synchroscope is a small motor with coils on the two poles connected across red and yellow phase of the incoming machine and the armature winding supplied from the red and yellow switchboard bus bars.

What is the synchronizing ?

The process of bring the voltage, frequency and phase angle of electrical supplies into line in order to be paralleled and share the loads.

Synchronising method

- ⇨ Synchroscope is the main method
- ⇨ Back-up methods are
  - ➔ Lamp dark method
  - ➔ Lamp bright method
  - ➔ Rotating lamp method or Sequence methods (preferable)

Sequence method

1) One of the lamps known as key lamp is connected in one phase
2) Other two lamps are cross-connected
3) If two frequencies differ, lamps will bright up in rotation. Clockwise indicates incoming machine is fast, and counter-clockwise indicates it is slow
4) Synchronising moment is when key lamp is dark and other two lamps equally bright
5) If phase rotation is wrong, all lamps will become bright and dark together. Remedy is to interchange any two phase connections

How to parallel the two generator with the aid of synchroscope ?

All meters and indicators must have in good working order.

- ⇨ Start the incoming generator with the correct staring procedure.
- ⇨ Check the working condition by readings pressure gauges, thermometer and audible and visual.
- ⇨ Watch for a minutes until prime mover come to stable.
- ⇨ Check the voltage of existing and incoming generator on the switchboard, **check trip if have reset.**
- ⇨ Move the selector switch to incoming generator. At that time, synchroscope pointer will rotate clockwise or counter clockwise direction.
- ⇨ Check the frequency and voltage of existing and incoming.
- ⇨ Carry out the adjustment by means of speed adjuster of prime mover to obtain the condition such that synchroscope pointer rotate in the clockwise direction at a speed of about 4sec/rev.
- ⇨ Close the circuit breaker of incoming generator when the pointer reaches just before 12’ O clock position.
- ⇨ Made off the selector switch.
- ⇨ Made load shearing the two generators by the speed adjuster of generator.

How do you parallel the two generators if synchroscope is out of order ?

If synchroscope is out of order, the two generators can be paralleled by emergency synchronizing lamps with sequence method.

The lamps are fitted as triangle forms, one on top and two on bottom.

To make parallel

Reset if any trip

- ✔ Move the selector switch to incoming generator. At that time, synchronizing lamps will give bright and dark sequence rotate clockwise or counter clockwise direction.
- ✔ Check the frequency and voltage of existing and incoming.
- ✔ Carry out the adjustment by means of speed adjuster of prime mover to obtain the required frequency and voltage.
- ✔ Adjust the speed to meet the slow clockwise direction.
- ✔ Incoming machine breaker is closed by hand when the top lamp (key lamp) dark and the both bottom lamps are equal brightness.
- ✔ Off the selector switch and make load sharing the two generators by speed adjusting.

How do you monitor the correct instant for synchronizing without the aid of synchroscope or synchronizing lamps ?

It can be synchronized with 500V voltmeter as follow.

- ⇨ Connect a pair of 500V voltmeter probes across the one phase of the incoming machine circuit breaker.
- ⇨ Adjust the generator speed until the voltmeter slowly fluctuates from zero to maximum.
- ⇨ Close the breaker when the voltmeter passes through zero.

Can you parallel the load of main G/E with emergency G/E and shore supply ?

It can not parallel, circuit breaker interlocks are arranged in this system?

Generator safety devices ?

1) Over sped rip
2) L.O low pressure trip @ alarm
3) F.O low pressure alarm
4) Jacket water high temperature alarm
5) Thermometer
6) Pressure gauge
7) L.O high temperature alarm
8) Dip stick
9) Crankcase relief valve

Methods of armature reaction compensation ?

- ⇨ By fitting inter poles between the main poles
- ⇨ By fitting carbon brush rocker
- ⇨ by fitting neutralizing winding

What is induction motor ?

It is a motor which run at a speed below that of the rotating magnetic field.

- ⇨ Squirrel cage induction motor

⇨ Slip ring induction motor.

Squirrel cage induction

1) Most widely used of all types of AC motors, due to simplicity, strength of construction and ease of maintenance
2) Made up of two main parts, rotor and stator and no direct electrical connection between them. No wire winding or slip rings.
3) Rotor has a series of plain bars (copper or Al) running in slots the length of the iron core
4) Each end of the bar is brazed into 2 heavy copper rings, one at each end. Those bars form a cage, that looks like squirrel cage
5) Stator has 3 separate windings supplied from a 3 phase AC supply
6) Phase difference 120 and umber of poles 2, 4, 6 or more, depending on speed required

Difference between Synchronous Motor and Induction Motor

❖ Synchronous motor is almost exactly the same as an alternator
❖ Induction motor cannot run normally at synchronous speed. It has slip

AC motor overloads protections

1) Magnetic overload relay
2) Thermal overload relay
3) Built-in protective device

Causes of motor overheat ?

⇨ Motor running @ overload
⇨ One phase failure (single phasing)
⇨ Defective cooling fan blades
⇨ Bearing failure
⇨ Poor ventilation
⇨ Misalignment

When phase failure occur, A.C motor run or not ?

When motor is running, the motor keep on running but over load and over heat will occur. When motor is starting, the motor can not run.

What is moving iron instruments ?

It is an instrument suitable for measuring A.C voltage or current as well as D.C voltage or current.

What is potentiometer ?

It is an instrument which is used to measure or adjust the potential different in the circuit.

What is moving coil instruments ?

It is an instrument used for D.C only and as voltmeter or ammeter.

Static Electricity

- ❖ Electricity at rest instead of in motion
- ❖ Electric charges may be induced by friction or atmosphere effect

Static Electricity in oil tank, Prevention

1) Earthing device, earth bond across flanges on pipeline
2) Inert gas

Single phasing

1) Single phasing occurs when one of the 3 phase circuits is opened, hence the remaining circuits carry excess current
2) One phase of the circuits becomes open, due to blown fuse, faulty contactor, or broken wire
3) It prevents a motor from starting, but a running motor may continue to run with this fault
4) For a running motor, it can be detected by overloaded device in supply line, or overheating
5) For an idle motor, it cannot be started
6) Due to single phasing, overheating in a stalled or running motor will cause, burnt out overloaded coil

Residual magnetism

1) Magnetism remaining in the fields of a generator, after exciting current is cut off
2) Residual magnetism is essential for initial generation of current, necessary for further
3) Build up shunt field strength
4) Generator may fail to excite, if there is loss or reversal of residual magnetism of the pole

Remedy, when generator fails to excite

1) Pass a current through shunt field coil in correct direction
2) Correct direction means the current will re-magnetise the iron core in the right way
3) Current for restoration can be obtained from another DC generator or from a battery. If battery is used fro re-magnetising: A 12 V battery is connected [exclusively]
    - ⇨ Across shunt field coil with the machine stopped
    - ⇨ Current flow in right direction, for a few seconds, only will establish the field
4) During this time faulty generator must be in stopped position

Excitation Loss

4) Energize with Battery
5) Tap with hammer to field coil core of Excitation Motor

Winless safety devices ?

- ⇨ Emergency stop
- ⇨ Overload trip
- ⇨ Over speed trip
- ⇨ Mechanical break
- ⇨ Slipping clutch for over load, to prevent any undesirable damage such as hull damage due to anchor and rope brake out.

Slipping Clutch

1) Slipping clutch is commonly fitted between prime mover and gearing
2) It is incorporated with motor, magnetic brake and drive shaft
3) Set to slip at approximately 133% of full load torque
4) Letting go or dropping speed is controlled by friction brake
5) Hauling speed is 0.15 m/sec

Why fitted ?

1) In windlass, undue stresses must not be applied to chain cable and machinery
2) Without slipping cultch, excessive stresses could be applied to cable, by armature momentum, by sudden obstruction when heaving, or when bringing the anchor into hawsehole
3) Fitted also to avoid inertia of prime mover being transmitted to windlass machinery in the event of shock loading on cable, when anchor is being housed
4) When ship is riding at anchor, bow stopper prevents the strain for windlass

Electric breaking system

1) When electric deck motor is used for lowering or lifting load, electric brake system is used. All brakes are failsafe types
2) In the event of power failure, brake automatically applied, thus preventing the load running back. A number of brake pads [free to move] are located in carrier, which is keyed to motor shaft
3) Armature plate applies pressure to brake pads, by means of a number of springs, to force against friction surface of back plate, so that it prevents the motor shaft from turning
4) When energized, armature plate is attached to magnet, thus releasing the thrust pressure and allowing the shaft to rotate

Winch brake adjustment ***:*** Adjust the distance between pressure plate and friction plate

Drying out of Electrical Machine

It is essential, when machine has been exposed to weather, or when accidentally immersed

When Electrical Machine is flooded with SW

1) Machine is disconnected from power sources and dismantled
2) All salt deposits washed out with FW
3) If deposited with oily bilge water, wash out with Electro Cleaner
4) Should be heated with lamp, and enclosed or covered up to retain the heat
5) Moisture should be escaped, by lifting the cover continuously or periodically
6) Hottest part of the machine shall not exceed 90 °C, while heating
7) IR readings and temperatures taken regularly, until constant value reach about 1 m Ω
8) Then spray the machine with insulation vanish
9) Assemble and out in service with low load, if possible

Short, open and grounded circuits

Short circuit : A low resistance path that actually shorten the intended path for the flow of current

Open circuit : The path for the flow of current is broken. A switch s one method of creating an “open” intentionally

Grounded circuit : A circuit that has come in contact with the earth, by coming in contact

somewhere in itself, or by a conductor which is connected with the earth

Shore connection

Shore connection box is provided at convenient position, to receive shore power supply, so that ship's generators can be shut down, in port or Dry Docking

Lloyd's requirement

1) Connection box contains a circuit breaker or isolating switch with fuses
2) Provided full information of supply system, normal ship voltage and frequency for AC current
3) Main Switch board must be provided with a link switch or a circuit breaker, voltmeter, ammeter, and an indicator to show that the cable is energized
4) For 3-phase supply with earth neutral and earthing terminal must be provided, for connecting the hull to shore side.
5) A phase sequence indicator is necessary to ensure correct connections
6) Means shall be provided for checking polarity, and terminals should be labeled

How will you check the frequency of shore power supply ?

- Shore power supply connection box shows phase sequence of shore power generator with bright and dark lights
- Frequency can be check at Main Switchboard, after shore supply is 'on' through link switch or circuit breaker.

Common faults in DC Generator and Motors

1) Sparking at brushes
2) Overheating
3) Failure to excite

Sparking at Brushes

1) Wrong brush position
2) Dirty commutators
3) Brushes not properly bedded
4) Incorrect spring pressure on brushes
5) Wrong grade of brush
6) Overloading

Overheating

1) Overloading
2) Blocking up of ventilation passages with dirt

Test for over current trip

By increasing current injectors ;(e.g. by using Welding Machine)

Test for Reverse Power Trip

By reducing frequency

Ward Leonard System

1) Used for fine control of shunt motor speed from zero to full in either direction
2) Able to give the motor a robust torque characteristic

3) Can be sued for motors of electric steering gears of ships with DC power
4) Used today on ships with AC power for deck machinery such as windlass, mooring winch etc.
5) Working motor, which powers the steering gear, windlass or other equipment is a DC machine, because speed control of these is easy

Method

1) A DC generator is driven by AC squirrel cage induction motor (AC powered ship) Output voltage of DC generator is applied as power supply to armature of working motor.
2) Speed and direction of working motor varies with magnitude and direction of applied voltage
3) Output voltage of DC generator is increased or decreased by Potentiometer, as magnetic field strength is altered by changing the field current to field windings of the generator
4) As output voltage of the generator varies, speed of the working motor also varies
5) Change of current flow direction, also by Potentiometer, through the field poles of the generator will cause the change in direction of generated current, supplied to the working motor and thereby also the running direction of the motor

How to change speed ?

Through Potentiometer ⇨ by changing the strength of field current to field winding of DC generator ⇨ out put voltage of DC generator changed ⇨ working motor speed is also changed (Adjusting field current by means of rheostat)

Control A.C motor

Adjusting nos. of poles by means of selector switch.

How to change direction ?

Through control handle movement of Potentiometer ⇨ by changing the direction of field current through field poles of DC generator ⇨ Direction of generated current is changed ⇨ running direction of working motor is changed

Motor earthing symptom

‡ 440V, low insulation alarm
‡ Earth lamp signal

Effect of motor earthing

‡ Over heat
‡ Burn out
‡ Get the smell
‡ Noisy

Fuse to Order

1) Amperage of the circuit (AC/DC)
2) Type of fuse wire (Tin or lead wire0
3) Standard Wire Gauge (SWG)
12 (0.104” dia) 14, 16, 18 or 20

Battery Order

1) Voltage
2) Ampere/hour
3) Size

4) Type (Lead Acid or Alkaline)

Switch board Survey, what documents to give to Surveyor ?

1) Voltmeter, Wattmeter, Ammeter Calibration test result
2) ACB test result (Survey result)
3) Control Circuit Safeguard test results (Safety trips and Alarm test results)
4) Maintenance reports
5) IR test results of each terminal; all 440 V and 220 V main circuit

Survey approved IR (mΩ) ⇨ 1 mΩ =10^6 Ω

Date to be given Surveyor for electrical survey

1) Voltmeter, Wattmeter, Ammeter calibration test result
2) ACB test result (Survey result)
3) Control Circuit Safeguard test results (Safety trips and Alarm test results)
4) Maintenance reports
5) IR test results of each terminal : all 440 V and 220 V main circuits
6) IR test results of all motors & their safety factors
   a. Test date, time, place
   b. Voyage No.
   c. Ambient temperature
   d. Weather condition, hot or humid
   e. Machine is hot or cold

Difference between DC and AC generators
DC generator has commutator and AC generator has slip ring

What is drop test ? (**Volt drop test)**

It s a kind of test for exploring the open circuit fault, short-circuit fault of an armature winding or a set of field windings it is more reliable check than the growler test.

Testing

1) Insulation test (Megga test)
2) Continuity test
3) Voltage test
4) Current test

How many types of motor starter

1) Direct on line starter
2) Star delta
3) Auto transformer
4) Rheostat

2 & 3 is to reduce the starting current

Static electricity.

- Electricity produced on dissimilar materials through physical contact & separation.
- Out going material negative, remaining material positive. After having high potential spark occur.
- This is occurs in thin oil. Explosion occurs when tank cleaning operation and gas freeing operation.

Protection

- In bunker pipes are electrically bonded and from ship earthing arrangement to shore.

- Inert gas maintains above cargo in the tanks.
- C.O.W operation must be start after pumping out $1M^3$ because of to make sure no water remain in the tank.

Open loop

The loop is open, there is no feedback and the action of the controller has no reference to the result it produces.

Manual control gives satisfactory results. In certain cases boredom, carelessness of the operator may lead to an end product of result that fails to meet the requirements. The arrangement may then decide to install automatic control. The controller must replace the human brain.

The close loop automatic control system.

In practical automatic control systems, the controlled variable must first be measured. This may require both a detecting (sensing) element and a measuring element, or two may be combined in a single unit; the measured value is then compared with the desired value in the comparison element.

The output from the comparator, commonly called the error, causes the amplifier to vary its output in such a way as to reduce the error.

Closed loop

In an automatic process the closed loop is formed by the sensor, which feeds back information of the final process. This feedback or closed loop, return into a mixing point or comparison point where it compares itself against reference or set point signal. Any deviation between these two signals will alter or adjust the control mechanism.

Open loop

An open loop is a manual process where by information is not feed back to the control system. A man is required to sight visually or read display information and then make an adjustment.

Data logger

That section of a computer in which is mounted a typewriter whose keys are controlled electronically. The data logger is capable of producing a printer record of off limit conditions. It can also produce a printed log of plant sensors at predetermined intervals or on demand.

Automation

Any or all of the combined processes used aboard ship that have the ability to control work, notify the operator of its status and warn of malfunctions. This allows less people to control more machinery in a more accurate and efficient manner.

NAVAL ARCHITECTURE

1. Bow thruster

Bow thruster are maneuvering devices which is fitted in an athwartship tunnel near to the bow and aft of the collision bulkhead. It gives additional maneuvering ability.

2. Bulwark

A barrier fitted at the deck edge to protect passenger and crew to avoid the loss of items overboard while the ship rolls excessively.

3. Why fitted D.B tank ?

It is fitted to prevent foundering (flooding) in the event of hull damage.

- To control the stability by ballasting
- To provide buoyancy
- To store F.W and F.O

4. Why fitted wing tanks ?

- To control the ship stability (healing)
- To carry cargo
- To store F.W and F.O

5. What is half beams ?

Transverse beams which are cut at hatch side coamings are termed half beams.

6. Water tight bulkhead ?

Water tight bulkheads are important element of transverse strength, particularly against racking stress.

They divide the ship into longitudinal subdivision.

They also give protection against fire and founder

They are → Collision bulkhead or fore peak bulkhead
→ After peak bulkhead
→ One bulkhead at each end of the machinery space

7. Collision bulkhead ?

Collision bulkhead is a forepeak watertight bulkhead to protect foundering and against racking stress.

It is fitted not less than 5% or not more than 7% of the ship length aft and stern at load water line.

It must extend to upper deck.

Stiffness may be spaced 600 mm apart.

Its water tightness can be tested by filling the fore peak tank to the level of water line or hose test along the boundary. No water leak through other sides.

8. After peak bulkhead ?

To enclose the stern tube in a watertight compartment.

This bulkhead need only extend to first deck above load water line, if it forms a watertight flat.

Plating in after peak bulkhead must be doubled or thickened around the stern tube to resist vibration.

9. How do you check water tight door's tightness ?

Watertight hatch cover and watertight doors' tightness can be check by chalk method or hose methods.

Chalk method-apply chalk to watertight flat sealing continuously.

→ Close the door tightly, then open
→ Check the watertight door sealing.

The chalk must have continuously around the watertight sealing, it has water tightness.

Hose method –

→ Close the watertight door or watertight hatch cover tightly.

→ Hosting with water jet with a pressure of 2 bar and directed to the sealing edges away from 1.5 m.

→ There must be no water leak through the other side.

→ That door or hatch are good in order for watertight.

10. Dead weight and light weight ?

Dead weight → is the weight of cargo, fuel, water, store etc. that a ship can carry.
Light weight → is ready to sea going but no fuel, no crew, no cargo.
Displacement = Dead weight +Light weight

11. What is windless?

It is a machine used for hosting or lowering anchor.

12. What is stern tube ?

It is a watertight tube enclosing and supporting the propeller shaft. It consists of a cast iron or cast steel cylinder fitted with bearing surface up on which the propeller shaft (enclose in a sleeve) rotates.

13. What is hatch coaming ?

The vertical plating bounding a hatch for the purpose of stiffening the edges of the opening and resisting entry of water to ship hull.

14. What is girders?

The continuous stiffening member which run fore and aft in a ship to support the deck.

15. Stealer strake, stringer, stringer plate ?

Stealer strake → A single wide plate which replace two narrow plates in adjacent strake of a ship.

Stringer → A horizontal stiffener fitted along the ships' side or a longitudinal bulkhead, in order to provide strength and rigidity.

Stringer plate → The outboard strake of plating on any deck.

Duct Keel

An internal passage of water tight construction (two longitudinal girders spaced not more than 2.0 m apart) running same distance along the length of the ship, often from the forepeak to the forward machinery space bulkhead.

To carry the pipe work, and an entrance is at forward machinery space via a watertight manhole.

Bulbous bow A bulb shaped under water bow which is designed to reduce wave making resistance and any pitching motion of the ship.

Camber Curvature given to a deck transversely. It is measured by the difference between the heights of the deck at side and centre. The camber amidships is frequently ***one fiftieth of the breadth of the ship.***

Carving note Form completed by the owner of the ship under construction. Gives details of tonnage, name, port of registry, etc.

Cofferdam Narrow void space between two bulkheads or floors that prevents leakage between the adjoining compartment.

Coffin plates They are used to connect stern frames to the flat plate keel. The stern frame is extended forward far enough, two or three frame spaces, to provide a good connection with a flat plate keel. The aft most plate of the keel, coffin plate is dished around the extension.

CRP Contra - rotating propeller. A propulsion arrangement with two propellers rotating in opposite direction on the same shaft.

Freeboard Vertical distance from the load water line to the top of the freeboard deck. Freeboard has considerable influence on sea worthness of the ship. The greater the freeboard larger is the above water volume of ship. This provided reserve buoyancy assisting the ship to remain afloat in the event of damage.

Types of keel Bar keel, Duct keel, Flat plate keel.

Freeing port an opening in the lower portion of a bulwark, which allows deck water to drain overboard. Some freeing ports have hinged gates that allow water to drain overboard but that swing shut to prevent seawater flowing in board.

Dead light A hinged steel cover, which is part of a port or scuttle. It is used to cover the glass in heavy weather.

Dead rise Athwartship rise of the bottom from the keel to the bilge. Also known as ' Rise of floor '.

Deep tanks Tanks extending from the bottom or inner bottom up to or higher than the lowest deck. They are often fitted with hatches so that they also may be used for dry cargo in lieu of fuel oil, ballast water of liquid cargo.

Devil's claw A stretching screw with two heavy hooks or claws. It is used to secure the anchor in the hawse pipe.

Displacement A ship floating freely displaces a mass of water equal to its own mass and this mass is known as the ship's displacement.

Light displacement is the displacement of the ship complete & ready for sea but no crew, passengers, baggage, stores, fuel, water, cargo on board. Boilers, if any, are filled with water to working level.

Load displacement is at the maximum permissible draught and is made up of the light displacement and the dead weight.

Docking plug A brass screw fitted in the garboard strake of the shell plating at the bottom of each compartment to drain the water, which remains in the ballast tanks while the vessel is in dry dock.

Flare. The spreading out of the hull form from the centre vertical plane usually in the fore body above waterline.

Floodable length The length of the ship that may be flooded without sinking below her safety or margin line.

Floors. They are transverse vertical plates those run across the bottom of the ship from the centre girder to the bilge. Watertight or oil tight floors are used to divide the double bottom space into suitable tanks.

Flush deck ship A ship constructed with an upper deck extending through out her entire length without a break or a super structure such as forecastle, bridge or poop.

Free surface Liquid in a partially filled tank that tends to remain horizontal as the vessel heels or rolls

Garboard strake. The strake of the bottom shell plating adjacent to the keel plate.

Intercostals. These are plates, angles, etc., fitted down between others or cut to allow other parts to pass through them. Side girders, parallel to the centre girder & fitted between the floors, are intercostals. Vessels of up to 20 meters in breadth must have one intercostal side girder on each side. Vessels of greater are to have two such girders on each side.

Kort nozzle A shroud or duct fitted around a propeller in order to increase thrust at low speeds. It is often fitted to tugs and trawlers.

Length, overall The extreme length of a ship measured from the foremost point of the stem to the aftermost part of the stern.

Length between perpendiculars The length of a ship between the forward and after perpendiculars.

The forward perpendicular is a vertical line at the intersection of the fore side of the stem and the summer load waterline.

The after perpendicular is a vertical line at the intersection of the summer load waterline and the after side of the rudder post or stern post, or the centreline of the rudder stock if there is no rudder post or stern post.

Lightening holes, Large apertures cut in floor plates, side girders, and tank bracket plates. In double bottom vessels they provide an access to the different cells for inspection and upkeep, besides taking weight off the structure, which is their principal object. In a general sense any hole cut in reduce weight without impairing strength.

Margin line. An imaginary line drawn 75mm below the bulkhead deck at the ship's side. It is the highest permissible location on the side of the ship of any damage water plane in the final condition of sinkage, trim & heel.

Margin plate The outboard strake of the inner bottom. When the margin plate is turned down at the bilge it forms the outboard boundary of the double bottom, connecting the inner bottom in the shell plating at the bilge.

Oxter plates. They are peculiarly curved plates, fitted where the stern frame meets the overhang of the stern.

Panting. The pulsation in and out of the bow and stern plating as the ship alternately rises and plunges deep into the water.

Permeability The ratio of water which can enter with the volume of the empty compartment.

Permissible length The length between bulkheads on a ship in order to ensure that it will remain afloat if one, or more, compartments are flooded. The permissible length is some fraction of the floodable length. The fraction is called the factor of subdivision.

Pintles. The pins of bolt that hinge the rudder to the gudgeons on the rudderpost.

Pleuger rudder An active rudder in which a small motor driven propeller is incorporated in a streamlined casing. Ship steering at very low speeds is thus possible and the rudder angle can be greater than 35degrees.

Pounding. The impact of the water surface against the side or bottom of a ship hull, whether caused by ship velocity, water velocity, or both.

Rising tanks. Double bottom spaces in which the inner bottom is higher at centre line than at sides. This arrangement has the advantage of allowing moisture from the cargo drain into the bilge pockets on each side.

Scantlings. The dimension and the thickness of rolled sections and the breadth and thickness of plates, which together compose the ship's structure or part of same.

Schottle rudder A Z or double right-angled drive mechanism in which the propeller operates within a duct. The propeller and the duct can be rotated in order to steer the driven vessel.

Sheer. The curvature of the deck in a longitudinal direction. It is measured between the deck height at amidships and the particular point on the deck. The forward shear is twice of the aft shear.

Sheer strake. The course of the shell plating at strength deck level.

Shoe plates. They used to connect the stem to the flat plate keel. The forward end of the shoe plate is dished around the stem, whilst the after end is flattened to connect with the keel plate.

Sole piece. The fore-and aft piece, forming the lower part of the stern frame in single-screw vessels extending from the propeller post to the rudderpost.

Standard fire test The exposure of a material of a specimen, in a test furnace to a particular temperature for a certain period of time.

Stealer plate. At the ends of a vessel, particularly at the bow, the width of the strake decreases and it is often desirable to merge two strakes into one, this being done by a stealer plate.

Stern -Cruiser stern - A spoon-shaped stern used on most merchant ships, designed to give maximum immersed length. Transom stern - A square-ended stern used to provide additional hull volume and deck space ships.

Stiff A vessel is said to be stiff if she has an abnormally large metacentric height. Such a ship may have a short period of roll and therefore will roll uncomfortably.

Storm valve. A check valve placed at the end of soil or scupper pipes discharging through the ship'
side near the waterline. It allows the water to discharge overboard but prevents seawater from backing up the pipe.

Streamline A line in a fluid such that its tangent at any point is parallel to the instantaneous velocity of the fluid at that point.

Stringer A fore-and-aft girder running along the side of a ship at the shell and also to the outboard strake of plating on any deck.

SWATH Small water plane area, twin-hull vessel. Twin torredo shaped hulls are fully submerged with streamlined fins or struts supporting the upper platform or deck. It is used for passenger carrying and research vessels because it provides a stable platform.

Tender A vessel is said to be tender if she has an abnormally small metacentric height. Such a ship may have a long period of roll but may list excessively in a strong wind and may be dangerous if a hold is flooded following a collision.

Tumblehome The slant inward from the vertical of a transverse section of a hull about the designed waterline.

Turbulence flow Fluid flow where the particle motion at any point is rapidly changing both in direction and magnitude.

Turning circle A circle moved through by a ship when the rudder is placed in its extreme position. It is a manoeuvred carried out on sea trial.

Buoyancy. When a substance is immersed in the water it will appear to suffer a loss in weight. Since the actual mass of the substance is not changed, there must be force acting vertically upwards to create the apparent loss of weight. This force is called the force of buoyancy, and is considered to act vertically upwards through a point called centre of buoyancy.

Reserve buoyancy. The watertight volume of a ship above the water line is called the reserve buoyancy. It can be defined as the buoyancy a ship can call upon to meet losses of buoyancy due to damage of the main hull. Its use in the general working of the ship is to provide a sufficiency of freeboard to make the vessel seaworthy.

Ships vibration
1. Synchronous or resonance vibration.
2. Local vibration.
3. Vibration due to external forces.

Gross tonnage.

This is the total of the under deck tonnage and the tonnage of the following spaces.

1. Any tween deck space between the second and upper decks.
2. Any enclosed spaces above the upper deck.
3. Any excess of hatchways over 0.5 % of the gross tonnage.
4. At the ship owner's option and with the surveyor's approval, any engine light and air space on or above the upper deck.

Exempted space

These are spaces, which are not measured for the gross tonnage calculation.

1. Wheel house, chart room, radio room, navigation aid room.
2. Spaces for machinery & condenser, stability tanks
3. Safety equipment and battery spaces.

4. Gallery, washing & sanitary.
5. Sky lights, domes & trunks.

Deducted space

The tonnage of these spaces must be measured first and may then be deducted from the gross tonnage of the ship to give the net tonnage.

1. Master & crew accommodation, provision store.
2. Chain locker, steering gear space, anchor gear and capstan space.
3. Workshop, storerooms.
4. Donkey engine & donkey boiler space, pump room. (Outside the machinery space)
5. Water ballast tanks. (maximum limit of 19 % of the gross tonnage is imposed)
6. Propelling power allowance.

Propelling power allowance (PPA)

This is the largest deduction and is determined according to certain criteria, as follows:

If the machinery space tonnage is

1. Between 13% to 20% of gross tonnage → PPA = 32% of gross tonnage.
2. Less than 13% of gross tonnage → PPA = proportion of 32% of gross tonnage.
3. More than 20% of gross tonnage → PPA = 1.75 times the machinery space tonnage.

Maximum limit of 55% of the gross tonnage for the PPA.

Net tonnage.

This is the tonnage value obtained by deducting from the gross tonnage the total value of the deducted spaces. The net tonnage is considered to represent the earning capacity of the ship.

CORROSION AND PREVENTION

The prevention of corrosion deals with the provision of (1) protective coating for the ship structure steel and its continued maintenance. Also a means of preventing electrochemical wastage is required, which is known as (2) *Cathodic protection*.

There are two types of cathodic protection method, *Sacrificial anode* system and *Impressed current* system.

SACRIFICIAL ANODE SYSTEM

Sacrificial anodes are metal or alloy attached to the hull, which have a more anodic potential than steel when immersed in seawater. These anode supply the cathodic protection current, but will be consumed in doing so and therefore required replacement for the protection to be maintained.

Sacrificial anode may be fitted within the hull, and are often fitted in ballast tank. Magnesium anodes are not used in the cargo tank of oil tankers owing to the spark hazard. Should any part of the anode for and strike the tank structure when gaseous condition exist an explosion could result.

Zinc anode may be safely employed.

IMPRESS CURRENT SYSTEM

The impress current system consist of a (1) source of direct current, (2) anodes, apparatus for (3) measuring and controlling the current and a (4) high quality inert protective coating around the area of the hull nearest to the anode.

Continuous control of the impress current required for adequate protection varies with the (1) immersed area, the (2) ship speed, the (3) salinity of the water and (4) condition of the hull paint work.

This control is usually obtained by the used of reference anode positioned some distance from the operating anode. If too great a current well to flow it could destroy paint coatings on the ship hull.

Around the anode a protective coating is epoxy resin is applied directly to hull for a radius of one meter or more, since highly alkaline condition arise near the anode. A propeller bonding arrangement must be fitted with impress current system to ensure propeller protection.

PREVENTION OF MARINE GROWTH AND FOULING

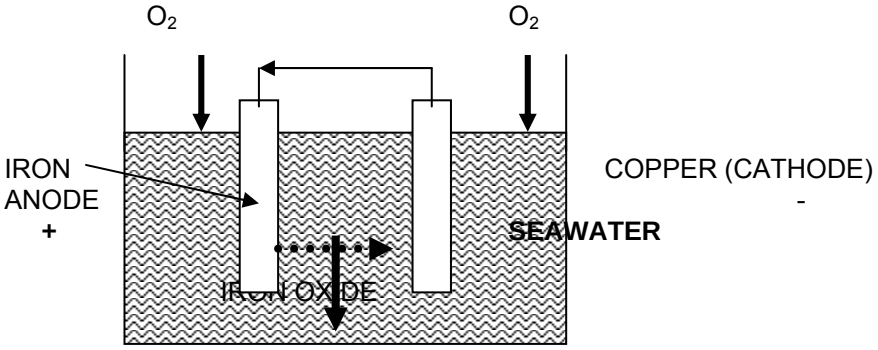
Anti fouling paint are used for this purpose. They consist of a vehicle with pigments (အရောင်ထွက်), which give body and colour together with materials poisonous to marine vegetable and animal growth.

Mercury and copper are the best-known poisons used in anti fouling paint.

To prolong the useful life of the paint the poisonous compound dissolve slowly in seawater. Once the release rate falls below a level necessary to prevent settlement of marine organism the anti fouling composition is no longer effective.

A recently developed anti fouling paint is non-toxic in operation it is based on a metallised acrylic polymer and psychically influences the film which form on immersed hull. Adherence by marine organism is made almost impossible by the paint altering the critical surface of the film.

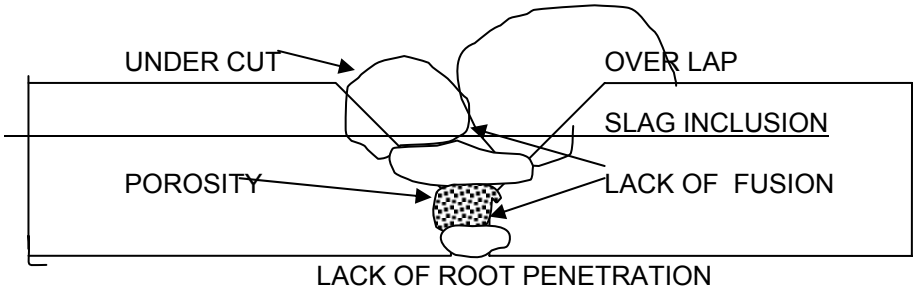
ATTACHEMENT OF ZINC BLOCK TO HULL



Many ship corrosion problems are associated with the coupling of metallic parts of differential, which consequently form corrosion cells under service condition. The corrosive rate of metal and alloy and seawater has been extensively investigated and as a result galvanic series of metal and alloys in seawater have been obtained.

Zinc block attached to the hull, in way of bronze propeller and other immersed fitting, have a more anodic potential than steel when immerse in seawater. These anodes supply the cathodic protection current, but will be consumed and doing so and therefore required replacement for the protection to be maintained.

DEFECTS ASSOCIATED WITH WELDING



OVER LAP

This is overflow of weld metal over the base metal without fusion (အရည်ပျော်၍စပ်ခြင်း). Failure of the joint is certain when the overlap is located at the toe (အခြေ) of the weld.

This is the serious defect and should be avoided. It may be caused by:

1. Low welding current
2. Fast travel
3. Improper electrode manipulation.

UNDER CUT

This is a cutting away of the base metal surfaces at the edge of the weld. It decreases the thickness of the metal at that point.

Any material reduction in the metal thickness also reduces the metal strength, thus causing joint failure since the designed load of the joint is based on the original metal thickness.

The possibilities of failure at this point are increased when under cutting occurs at the toe of the weld; a point there is high stress concentration. This defect is caused by:

1. Improper arc manipulation.
2. Slow travel
3. Excessive welding current.

POROSITY

It is the presence of pockets containing gas, in the welds. Excessive porosity in metal arc welds has a serious effect on the mechanical properties of the joint.

Avoiding best prevents porosity:

1. Overheating and under heating of the weld metal,
2. Too high a current
3. Too long in arc.

SLAG INCLUSION

Slag inclusions are elongated or globular (အလုံး) pocket of metal oxides and other solid compounds. It may be caused by concentration of the weld metal by foreign bodies.

In multi layer welding process, failures to remove the slag between the layer cause slag inclusion. Preparing the groove and weld properly before each beat is deposited can prevent most slag inclusion, making sure that all slag has been removed and cleaned from the surface of the previous bead.

LACK OF PENERATION

This is the failure of the *filler in base metal to fuse together* at the root of the joint. Lack of penetration will cause weld failure if the weld is subjected to tension or bending stresses.

This may be due to:

1. Incorrect joint design,
2. Fast travel
3. Electrodes too large
4. Current setting too low.

LACK OF FUSION

Lack of fusion is the failure of a welding process to (1) *fuse together layers of weld metal* or (2) *weld metal and base metal*.

This is generally referred to as overlap. Lack of fusion is caused by failure to raise the temperature of the base metal or the previously deposited weld metal to the melting point.

Reason for this failure include:

1. Too small electrode
2. Too fast travel
3. Too close and arc gap
4. Too low welding current.

DISTORTION

It is caused by uneven heating and cooling, which involve the expansion and contraction of the base metal. The heat can be controlled by back-step welding sequences, by clamping the parts into their original position in a special fixture, and by single beat welding, which means that instead of making two or three passes with small diameter electrodes, one parts is made with a large electrode.

Distortion can be eliminated by increasing the welding speed and by closing the distance between the parts to be welded.

CENTER LINE CRACKING

It is caused by the inability of base metal to move when the weld solidify and contracts, by using incorrect electrodes, by using in balance of base metal masses or in too high carbon content in the base metal.

This can be eliminated by

1. Design the joint correctly,
2. Preheating the parts to be welded prior to welding,
3. Maintaining the preheat temperature in the base metal during process,
4. Allowing the base metal to move freely as the welding process takes places
5. Stress relieving the welded parts as soon as the operation completed.

FIRE FIGHTING ARRANGEMENT

Since fire on board is very dangerous and Shore Professional Fire Brigade can not be call at sea thus fire prevention is vital. Fire prevention included regular fire drills on board with proper training.

PREVENTION

(1) CLEANLINESS:

a) No oils, oily rags and wastes should be allow in the vicinity of the heat source such as the places of (Boiler, Heaters and M/E exhaust system). They are liable to ignite spontaneously.
b) No oil leak should be tolerated (တင်းခံသည်) such as from oil tank's trays and drip pan, fuel and lube oil separator's trays, fuel and lube oil valves, oil burners and piping connection.
c) Tank top and bilges should be cleaned and hose down frequently. Cleaning could be done with some chemical such as oil spill dispersant if oil accumulated considerably.
d) Tank tops and bilges should be painted white and these place illuminations (မီးထွန်းထားခြင်း) to be provided.

(2) HEAT SOURCES

Should be preventive and minimize.

a) No naked lights and smoking should be allowed inside the engine room and near the bunker.
b) Paint should be stored in special well ventilated stored away from machinery space or heat source and automatic water sprinkler system to be provided as per latest regulation.
c) Welding practice should be done only in workshop and away from combustible material storing spaces carefully, then all the protective cloths to be put on and earthing should be ensured.

(3) FIRE FIGHTING APPLIANCES

Should be kept in working order:

a) All portable extinguishers and semi portable one to be ensured in good working order and properly placed inside the machinery space and always made handy.
b) Fixed fire fighting installation should be test once a week and it's maintenance to be done periodically such as compress air blowing of lines and discharge nozzle and alarm testing and function testing. The contents inside the unit to be weight or checked periodically.
c) Emergency fire pump should be kept in good working order and test run to be done weekly without any failure.
d) Fire detection, monitoring alarm system to be tested to weekly without any failure.
e) All fire hydrants and their connection should be kept in very good order also to the sandboxes and scoop.
f) Fire men outfits two numbers should be also kept in good order and handy at all time.
g) International should be placed at proper location and to be in good order.
h) All engine room members should be properly educated about fire fighting appliances and their operation.
i) Fire drill should be carried out at least once a month.

WHEN FIRE BREAK OUT

a) IF THE FIRE IS SMALL

Find the origin of fire, inform to C.E and all engine room member, restrict is not to spread out if possible and extinct it on the spot with potable extinguisher or by another means. (In practice, as soon as, noticing of the break out of fire, the fire alarm or emergency alarm must be activated before taking any action.)

b) IF THE FIRE IS IMMEMSE (အလွန်ကြီးသော**)**

I. Sound fire alarm system.
II. Evacuate all ship crew, count them and assign as per muster list.
III. Remote stopping of all fuel pump to be done.
IV. Remote closing of all quick closing to be done.
V. Remote closing of skylight door and engine all watertight door to be done.
VI. Remote closing of all engine room ventilation damper to be done.
VII. Prime mover and all machinery to be stop.
VIII. All engine room entry and exit door to be closed perfectly.
IX. All ventilation fan in engine room to be stopped manually.
X. Fire fighting fixed installation system to be operated by C/E or 2/E in a very proper manner.

SPACE MINIMUM REQURIEMENT IN MACHINARY

I. Two numbers of fire hydrants with hoses, which can extinguish when any place of fire occurs in engine room. (Minimum)
II. Ten feet tube of sandboxes and with scoop.
III. One fixed installation of CO_2 or foam or Halon.
IV. Portable extinguisher of at least two numbers of 2 ½ gal of foam or CO_2 (Numbers of portable extinguishers depends on the BHP of engine).
V. Semi portable extinguisher of 45 kg of CO_2.
VI. Dip pans and trays for every F.O and Lube oil tank.
VII. Monitoring detection and alarm system.
VIII. Emergency fire pump.
IX. Two numbers of main fires pumps.
X. International shore connection.
XI. Inert gas system.

RUDDER

Types of rudder.

1. Unbalanced rudder ~ A rudder with all of its area aft of the turning axis.
2. Semi-balanced rudder ~ A rudder with a small part of its area, less than 20%, forward of the turning axis.
3. Balanced rudder ~ When 25% to 30% of the area is forward of the turning axis there is no torque on the rudder stock at certain angles.

It is usual to limit the rudder angle to 35 degrees on each side of the centreline, since, if this angle is exceeded, the diameter of the turning circle is increased.

The rudder is used to steer the ship. The *turning action* is largely dependent on the *area of the rudder*. The required area of the rudder *varies* with different type of vessels since (1) desire maneuvering ability differs considerably and the general (2) ship design may imposed restriction. In practice the rudder area is usually relative to the *area of the immersed metal plane*.

The ratio of the *depth to width of a rudder* is known as the *aspect ratio* and is usually region two.

When a rudder is turn from the centerline plane to any angle, the water flows round the rudder and creates an additional resistance on that side of the centerline, **the force** that acts on the rudder parallel to, the centerline to the two **components**.

1. The force created by formation of streamline around the rudder that is due to change in direction of the water.
2. The suction on the after side of the rudder caused by eddying (ရေပြန်ဝဲဂရုက်).

The force on the rudder **depend on**

1. Area of the rudder
2. The form of rudder
3. The speed of the ship
4. The angle of helm (ပဲ့ထိန်းလက်ကိုင်)

Rudder may be [1] hinged on the pintles and gudgeons, or the may turn about and [2] axle which passes down through the rudder.

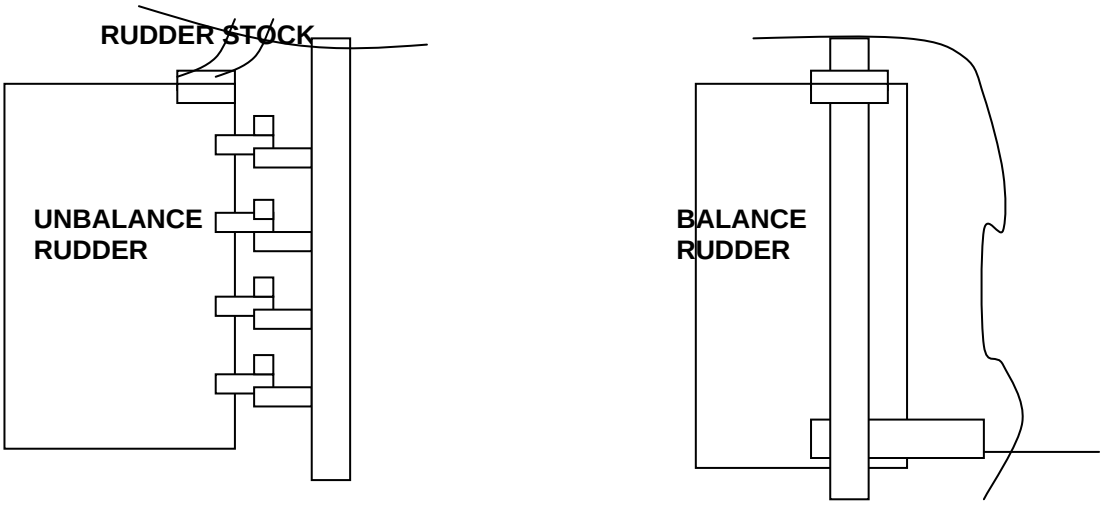
The **weight** rudder may be taken by [1] bearing pintles, or by a [2] bearing at the rudder head (carrier), or by a [3] combination of both.

A rudder with all of it *area aft of the turning axis* is known as **unbalanced rudder**.

A rudder with a *small part of its area*, *less than 20%, forward* of the turning axis is **semi-balance** rudder.

When *25%~30% of the area is forward* of the turning axis there is *no torque on the rudder stock* at certain angles and such an arrangement is therefore known as a **balanced rudder**.

It is usual to limit the rudder angle to 35' on each side of the centerline, since, if this angle is exceeded, the diameter of the turning circle is increased.



CONSTRUCTION

Modern rudders are of *stream lined form* and are *fabricated from steel plate*, the plate size being stiffen by internal webs. Where the rudder is fully fabricated, *one* side *plate* is *prepared* and the *vertical and horizontal stiffening webs are welded to this plate*.

The other plate often called the *closing plate* is then welded to the internal webs from the exterior only. This may be achieved by welding, flap bars to the webs prior to fitting the closing plate, and then *slot welding the plate*.

The *upper face* is formed into a usually *horizontal flat palm* (လက်ဖဝါး), which acts as the *coupling point* for the rudderstock.

A *lifting hole* is provided in the rudder to enable a *vertical inline* lift of a rudder when it is being *fitted or removed*. This lifting hole takes the form of a short piece of tube welded through the rudder with doubling at the side and closing plate.

A *drain hole* is provided at the *bottom* of the rudder to check for *water entry* when the ship is *examined* in dry dock.

To *prevent internal corrosion* the interior surfaces are suitably *coated*, and in some cases the rudder may be filled with *inert plastic foam*.

The rudder is *tested* when complete under a *head* of water *2.45* M above the top of the rudder.

RUDDER BEARING

The rudder is supported by *pintles*, which fits into the *gudgeons*. The upper parts of each pintle are *taper and fit into* a similar taper and in the rudder gudgeons. The pintle is pulled hard against the taper by means of a nut with some suitable locking device.

A brass liner if fitted around the lower part of the pintle. The lignum vitae or synthetic materials like Tufnol are used for bearing.

Bottom pintle is known as bearing pintle. It rest on harden steel disc. A hole is *drilled in the gudgion*, with a *smaller hole in the bearing pads* to allow for the free *circulation of water* which act as the *lubricant* for bearing, an along the bearing disc to be punched out when worm.

The weight of the rudder may be carried partly by the lower pintle and partly by a rudder carrier within the hull.

In some rudder type, for example, the spate types which only supported within the hull. The carrier carries the full weight.

A rudder carrier may incorporate the *watertight gland fitted* at upper end of the rudder trunk. Most of the rudder's weight may come onto the carrier bearing if excessive wear down of the lower pintle occur, and the bearings have cast iron cone which limit the wear down.

Inclining experiment

Results are used for "High of the transverse metacentre above the keel may be found from the metacentric diagram and hence the high of the center of gravity of the ship may be determined".

- All ship rope must be slackened
- All tank must be full or empty
- All moving parts are securely tighten
- Ship must be upright

A small mass 'm' is moved across the ship through a distance 'd'.

If Δ is the displacement of the ship, $GG_1 = \frac{m \times d}{\Delta}$

But $GG_1 = GM \tan \theta$

$GM \tan \theta = \frac{m \times d}{\Delta}$

$GM = \frac{m \times d}{\Delta \tan \theta}$

L = length of the pendulum, so $\tan \theta = \frac{a}{L}$

$GM = \frac{m \times d \times L}{\Delta \times a}$

Slip

Apparent slip

Since the propeller work in water, the ship speed Velocity will normally be less than the theoretical speed. The difference between the two speeds is known as Apparent slip and is usually express as a ratio or percentage of the theoretical speed.

$$\text{Apparent slip} = \frac{\text{Theoretical speed } \{V_T\} - \text{ship speed } \{V_S\}}{\text{Theoretical speed } \{V_T\}} \times 100\ \%$$

Real slip or true slip

This is the difference between the theoretical speed and the speed of advance, express as a ratio or percentage of the theoretical speed.

The real slip is always positive and it dependant of current.

$$\text{Real slip} = \frac{\text{Theoretical speed } \{V_T\} - \text{speed of advance } \{V_A\}}{\text{Theoretical speed } \{V_T\}} \times 100\%$$

SPEED LENGTH RATIO USED FOR FROUDE'S LAW OF COMPARISON

If $Rr \propto L^3$, then $V \propto \sqrt{L}$ $\qquad \frac{V}{\sqrt{L}} = \text{Constant} \quad \frac{V_1}{\sqrt{L_1}} = \frac{V_2}{\sqrt{L_2}}$

Above expression is known as speed length ratio.

Where Rr = residual resistance
L = linear dimension of vessel
V = speed of vessel

1. At corresponding speeds the wave-making characteristic are the same.
2. At high speed the speed length ratio is high and the wave making resistance is large.
3. A ship is therefore consider slow or fast in relation to it's speed length ratio.

If ratio is below 1.0 the ship is said to be slow. If ratio is above 1.5 the ship is said to be fast. Thus a speed of 15 knot would be regarded as slow for a ship 225M long, but fast for a ship 100M long.

STRESS

The modern ship is made up steel plating, section and builds up girders so connected as to provide adequate strength in all parts to withstand the forces acting on the ship under all condition of service.

The forces acting on a ship may be static or dynamic.

The static forces are due to the *difference in the weight and buoyancy*, which occur through out the ship.

The dynamic forces are cause by (1) the motion of the ship at sea and (2) the action of the wind and (3) wave.

These forces create:

1. Longitudinal stress
2. Transverse stress
3. Local stress.

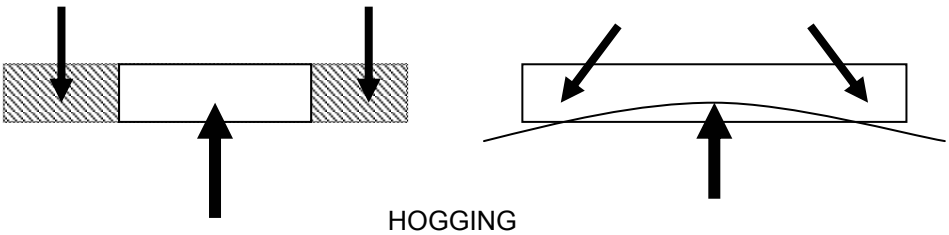
The greatest stress set in the ship as wholes are due to the distribution of load along the ship, causing longitudinal bending.

LONGITUDINAL STRESS

The forces are two in number, the (1) *weight of the ship and all that it carries* acting down wards and the vertical component of the (2) *hydrostatic pressure*.

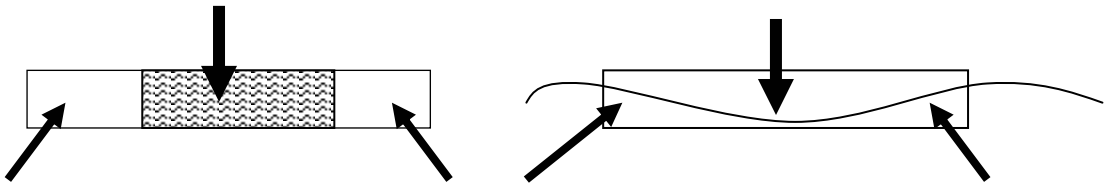
Depending upon the direction in which the bending moment acts the ship will Hog or Sag.

Hogging. If the (1) buoyancy amidships exceed the weight due to loading or when (2) the wave crest (လှိုင်း ထိပ်) is amidships, the ship will Hog, as a beam supported at mid length and loaded at the end.



HOGGING

Sagging If the (1) weight amidships exceed the buoyancy or when (2) the wave trough (လှိုင်းခွက်) is amidships the ship will sag, as a beam supported at a ends and loaded at mid length.



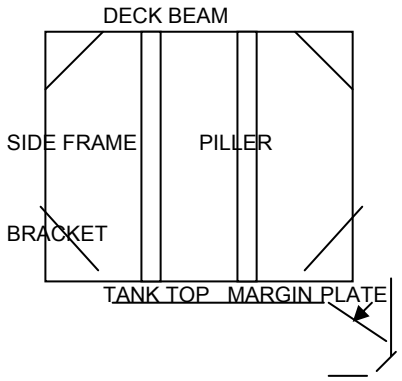
SAGGING

TRANSERVES STRESS

A transverse section of amidships is subjected to static pressure due to the (1) surrounding water as well as (2) internal loading due to the weight of the structure, cargo, etc.

The parts of the structure, which resist transverses, are

1. Transverse bulkhead
2. Floor in the double bottom
3. Bracket between deck beam and side frame, together with bracket between side frame and tank top plating, or margin plate
4. the pillars in hole and tween deck.



LOCAL STRESS

These are created by such item:
a: Heavy concentrated load like boiler, engine etc.
b: Dead cargo such as timber
c: Hull vibration
d: Ship resting on block on a dry dock.

DYNAMIC FORCES

The dynamic effects arise from *the motion of the ship* itself. A ship among waves as three linear motions.

1. Vertical moment (Heaving)
2. Transverse moment (Swaying)
3. Fore and aft moment (Surging) and three rotational motion.

a. Rolling about longitudinal axis
b. Pitching about a transverse axis
c. Yawing about a vertical axis

When the ship motions are large particularly in pitching and heaving, considerable dynamic forces can be created in the structure.

PANTING

As wave passes along the ship they cause fluctuation in water pressure which tends to create in and out movement of the shell plating. This is particularly the case at the fore end.

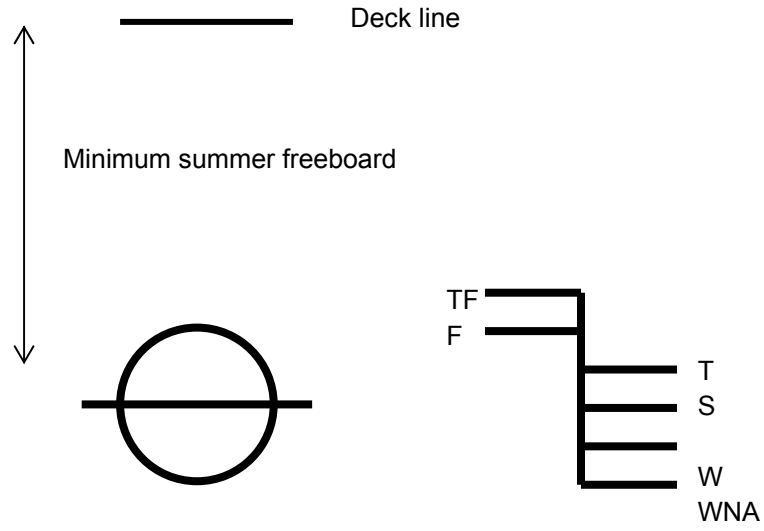
The rules of the classification societies required extra stiffening, at the end of the ship, in the form
of beams, brackets, stringer plate, etc: in order to reduce the possibility of damage. This in and out movement is called panting.

SLAMMING OR POUNDING

In heavy weather when the ship is heaving and pitching, the fore end emerges from the water and reenters with a slamming (ရိုက်သည်) effect which is called pounding.

Extra stiffening require at the fore end to reduce the possibility of damage.

Load line. The load line is a term given to a mark located amidships on both sides of a ship to show the limiting draught to which the vessel may be loaded. This limiting draught is obtained by measuring from the uppermost continuous weather tight deck (normally the freeboard deck) down to the load line mark amidships. This distance is called the freeboard of the ship.



Corrosion prevention

1. Protective coating.
2. Cathodic protection.

(a) Sacrificial anode system, (zinc anode)

(b) Impressed current system.

1. Direct current 2. Anodes 3.Appratus for measuring and controlling the current and 4.High quality inert protective coating around the area of the hull nearest to the anodes (epoxy resin, around the anode radius one meter or more.

Continuous control of the impressed current required for adequate protection varies with the 1.Immersed area 2. Ship speed 3. Salinity of the water and 4. Hull paints work.

1. Reference anode, 2. Operating anode.

Too great a current ~ destroy paint coating.

Fitted propeller shaft bonding arrangement.

Prevention of marine growth and fouling.

Antifouling paint (Give body & colour together with materials poisonous to marine vegetable and animal growth.)(Eg ~ Mercury, copper)

Dissolve in slowly in seawater. Release rate falls below a level necessary to prevent settlement of marine organisms the anti-fouling composition is no longer effective.

Developed anti fouling paint - non-toxic in operation. It is based on metalised acrylic polymer and physically influences the film, which forms on immersed hull. Adhere by marine growth is made almost impossible by the paint altering the critical surface tension of the film.

Pilgrim nut

1. The pilgrim nut provides a predetermined grip between the propeller and its shaft.
2. The propeller boss is fitted with a S.G cast iron internally tapered sleeve, which is secured (fixed firmly in position) into the boss. This sleeve is bedded to the shaft cone before mounting in the boss so that better fit is achieved which, combined with the pilgrim nut push up, ensure a good friction grip. No key is required.
3. The pilgrim nut is a threaded hydraulic jack, which screwed on to the tailshaft. A steel ring receives thrust from a hydraulically pressurised nitrile rubber tyre. This thrust is applied to the propeller to force it onto the taper sleeve.
4. Propeller removal is achieved by reversing the pilgrim nut and using a withdrawal plate, which is fastened to the propeller boss by studs. When the tyre is pressurised the propeller is drawn off the taper.

Advantages

1. The sleeve has a similar thermal expansion to the steel shaft, thus reducing the risk of slackness in hot water.
2. An extension to 5 years survey period is allowed by classification societies.
3. The boss stress are reduced.
4. The cast iron/ steel contact has a higher friction coefficient than bronze/ steel.

Stern tube The water tight tube enclosing and supporting tail end shaft. It consists of a cast iron or cast steel cylinder fitted with bearing surface within which the tail shaft, enclosed in a sleeve, rotate.

Stern tube (water lubricated)

The forward end is flanged and studs are used to secure the flange to the after bulkhead, a make up liner of lead or wood being inserted between the two. The forward end is supplied with a stuffing box packing and gland to keep water out of the tunnel and aft with a bearing, four times the shaft diameter in length, composed of lignum vitae, the wood strips being fitted dovetail (wedge-shaped joint) fashion into the brass bush.

Waterways are left between lignum vitae strips to allow access of water to the shaft after bearing. The wood strips are kept in place forward by a lip on the bush and aft by a check ring. The bearing cannot attain a fully hydraulic film, mainly due to low viscosity of water and there is considerable rubbing contact with consequent (direct result of something) wear.

Normal clearance is 0.003 to 0.004 of diameter of the shaft.

Stern tube (oil lubricated)

Two bushes are pressed into a stern tube which itself pressed into the ship's stern frame. Mechanical seals are provided at both ends of the stern tube, which is filed with oil, maintained at slightly above sea water level pressure by means of a static pressure header tank providing at a considerable height.

Running in oil bath, the shaft is not required sleeve for protection. The classification will generally accept the continuous length of bearing metal at 1.5 to 2.0 of the shaft diameter at the after end with calculation that the specific load does not exceed 0.8 N/mm^2 and at

0.6 to 1.25 of the shaft diameter at forward end. The bush is gray or nodular cast iron which are lined centrifugally with white metal.

Oil clearance usually provides is 0.0015 to 0.002 of the shaft diameter.

Advantages of Oil lubricated

1. Oil is better lubricant the water
2. Oil is Lower frictional coefficient than water. So less wear and score etc..
3. White metal oil film lubrication can carry more load.
4. Bearing surface reduced.
5. No sleeve required in tail shaft.
6. No abrasive particle like seawater causes wear and corrosion.
7. Oil act to improve vibration damping.

Stern tube seals

1. Simple stuffing box.
2. Lip seal.
3. Radial face seal.

Pressure test of cargo tanks.

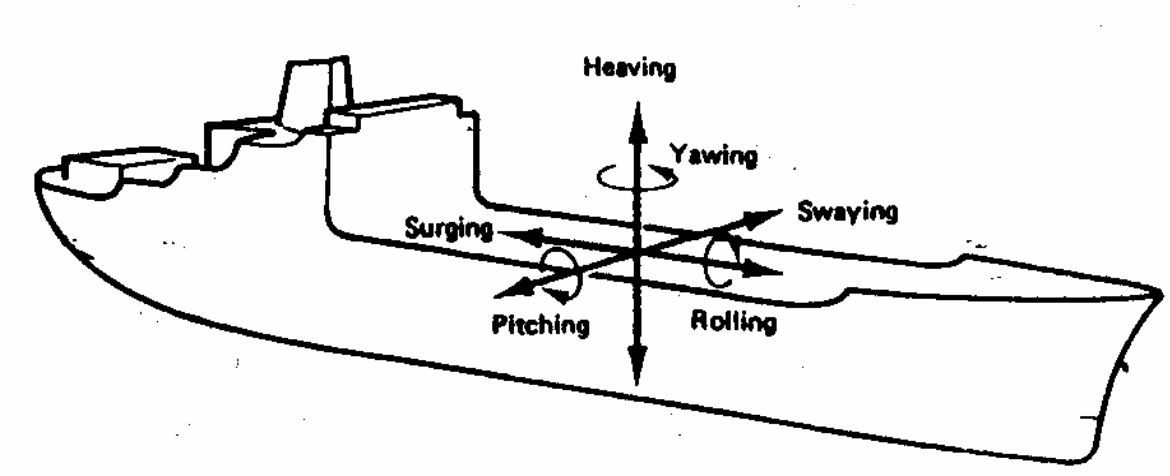
1. A structural test by testing with water to a height of 2.45 meters above the tank crown, or
2. A leak test consisting of a soapy solution test while the tank is subjected to an air pressure of 0.14 bar. It is recommended that the air pressure is initially raised to 0.21 bar and then lowered to the above test pressure before inspection is carried out.

Water tight doors

Watertight bulkheads are constructed to ensure their water tightness. Where openings are necessary in these bulkheads special watertight doors must be fitted.

SHIP MOTION

Linear / Translation Motion along x → Surging, along y → Heaving, along z → Swaying



1) Surging → The forward and aft liner motion (along x) of a ship is called surging
2) Heaving → The vertical up and down linear motion (along y) of a ship is called heaving
3) Swaying → The side to side linear motion (along z) of a ship is called swaying
4) Rolling → The rotational motion of a ship about longitudinal axis is called rolling
5) Yawing → The rotational motion of a ship about vertical axis is called yawing
6) Pitching → The rotational motion of a ship about transverse axis is called pitching

Hogging: the condition of a ship when distribution of weight and buoyancy along its length is such that the buoyancy amidships exceeds the weight
Sagging: The condition of a floating ship when distribution of weight and buoyancy along its length is such that the weight amidships exceeds the buoyancy.

Pounding / Slamming: The effect resulting from the rise and fall of the forward end of a ship when heaving and pitching.
Dynamic Stress : The transverse distortion of ship's structure due to acceleration and deceleration during rolling.
: It is greatest when the ship is in light or ballast condition. It is prevented by beam knee and bracket.
Static Stress: **I**n dry dock if the vessel is not properly placed on keel block, the static stress may set up.

Difference between Stiff on ship and Tender ship

Stiff Ship	Tender Ship
★ Greater GM due to high density cargo on bottom ★ Ship rolls very fast ★ Very uncomfortable	★ Small GM (but not negative) due to loading on top ★ Ship rolls very slowly ★ Uncomfortable but better than stiff ship

What are tunnel water tight door requirement ?

1) The door may be either vertical or horizontal sliding
2) The means of closing the door must be positive ie. They must not rely on gravity or a dropping weight
3) They capable for operating with a list of 15 degree and to be capable of being quickly closed form an accessible position above the bulkhead deck
4) It must be operated from the vicinity of the door in addition to a point above the bulk head deck
5) If no power is available in hydraulically operated system,
6) The door may be closed and opened by manual operated pump
7) Must have an index at the operating position showing whether the door is opened or closed.

SCAVENGING AND SUPERCHARGING

Purpose of compressed air onboard.

1) Starting of engine.
2) Instrumentation control air.
3) General purpose air.
4) Whistle air.

What is scavenging ?

Scavenging is the process of removing the burnt gas in the engine cylinder by means of incoming charged air.

Scavenging efficiency ?

$$\text{Scavenging efficiency} = \frac{\text{Wt of air enter into the cylinder}}{\text{Wt of air for stroke volume}}$$

How many types of scavenging? Which one is the best and why ?

There are three types of scavenging

1. Cross scavenging
2. Loop scavenging
3. Uniflow scavenging

Uniflow scavenging is the best because of high scavenging efficiency. The air inlet and exhaust do not change in direction in passing through the cylinder. The possibility of short circuiting or excessive mixing is therefore reduced.

How do you understand the 3 kinds of scavenging ?

Cross scavenging

The air inlet and exhaust ports are arranged at the same end of the cylinder liner and they are placed opposite to each other. Scavenging efficiency is 0.75 to 0.8.

Loop scavenging

The air inlet and exhaust ports are arranged at he same end of the cylinder liner but the exhaust ports are on the top of the inlet ports. Scavenging efficiency is (0.8 to 0.9).

Uniflow scavenging

The air inlet ports and exhaust ports or valves are arranged the opposite ends of the cylinder liner. Scavenging efficiency is more than 0.9.

Advantages of loop scavenging ?

It has no exhaust valve and its driving mechanism .It saves the energy losses to drive the exhaust valves.

Major requirement for the loop system ?

- ⇨ The inlet air ports are angled to give rotary swirling effect to the incoming air.
- ⇨ It also required long piston skirt or exhaust timing v/v to prevent scavenging air leak into exhaust while the piston is at top of it's stoke.

Disadvantages of cross and loop scavenging ?

- ⇨ The air inlet and exhaust ports are arranged at the same end of the cylinder.
- ⇨ The air and exhaust gas change in direction in passing through the cylinder.
- ⇨ Short circuiting or excessive mixing may occur.
- ⇨ Thus reduce the scavenging efficiency.
- ⇨ It require long piston skirt or exhaust timing v/v is necessary to prevent scavenge air leak into the exhaust while the piston is at top of its stoke.
- ⇨ It has thermal stress between scavenge and exhaust ports.

What is super charging ?

It is the process of the increasing of the wt of the charged air by increasing the density of the charged.

What is turbocharging ?

It is one kind of supercharging by using exhaust gas turbocharger. In which the energy in the exhaust gas expelled from the engine cylinder is utilized in driven in gas turbine, which is connected to a centrifugal air blower and air is supplied to scavenge air trunk.

What do understand constant pressure and pulse system ?

Constant pressure system

- Exhaust gas from all cylinders into a common large manifold where pulse energy is largely dissipated.
- The gas flow will steady rather than intermitted and at a constant pressure at turbine inlet.

TC arrangement

- No exhaust grouping
- Exhaust gases enter into large common manifold and then to turbine
- Firing order not considered

Advantages and disadvantages for constant pressure system?

Advantages

- Good performance in high load (Efficient when Bmep is above 8 bar)
- More suitable for high output engine.
- There is no need to group the cylinders exhaust into multiple of three. (Simple piping system) *No exhaust grouping*
- High turbine efficiency due to steady flow.
- The work transfer at the turbine wheel is smooth.
- Reduction in SFOC of 5% - 7%

Disadvantages

- When running at reduced speed and starting up low available energy at turbine. Thus it supplies inadequately air quantity of the scavenge pressure necessary for efficient scavenging and combustion. It required scavenge assistant.
- Poor response in changing load.

Pulse system

- Makes full use of the higher pressure and temperature of the exhaust gas during the blow down period and rapidly opening the exhaust valves
- exhaust gas leave the cylinder at high velocity as pressure energy is converted into kinetic energy to create the pressure wave or pulse in exhaust, lead to the turbocharger.
- *Exhaust pipe, so constructed in small diameter, is quickly pressurized and boosted up to form pressure pulse or wave*
- *Pressure waves reach to turbine nozzles and further expansion takes place.*

TC arrangement

- Interference exists between exhausting and scavenging among cylinders
- To prevent this, cylinder are grouped relatively with connections to two or more exhaust pipes
- Pipes are arranged, in small diameter to boost up pressure pulse and in short, straight length to prevent energy loss
- Number of exhaust branch depends upon firing order, no: of cylinders and TC design

Advantages and disadvantages of pulse system ?

Advantages

- At low load and low speed it is more efficient (Still efficient when Bmep is < 8 bar)
- No need assistant of scavenge pump and blower at any load change.
- It is highly response to change engine condition giving good performance of all speed of engines. *High available energy at turbine*
- Good TC acceleration

Disadvantages

- The exhaust grouping is complicated.
- Different sizes of exhaust pipes are needed for spare.
- High pressure exhaust from one cylinder would pass back into another cylinder during the low pressure scavenging period thus adversely effecting the combustion efficiency.

Under piston pressure

1) It is a type of constant pressure charging system
2) Air charged by T/C is passed through CAC into first stage manifold, and then through non-return valves into second stage and under piston space
3) In down stroke, piston under side compress further the scavenge air
4) Differential pressure shuts the inlet non-return valves as scavenge ports are uncovered, and a pulse effect is given to cylinder

Advantages

- Assist tangential swirl and ensure complete evacuation of remaining exhaust gas
- No auxiliary blower may be required, during manoeuvring

What is the turbocharger surging ?

When the discharge volute pressure exceed the pressure built up in the diffuser and the impeller. It produces a back flow of air from discharge to suction and it is characterized by noise and vibration of turbocharger.

Cause of turbocharger surging ?

It is caused by –

- ⇨ Scavenge space fire / Exhaust trunking fire
- ⇨ Poor power balance
- ⇨ Dirty nozzle and blades
- ⇨ Individual cylinder misfire
- ⇨ Chocked scavenge /exhaust ports
- ⇨ Suddenly load change by heavy sea
- ⇨ Incorrect matching of turbocharger to engine.
- ⇨ Poor scavenging or leaky exhaust valve

What is exhaust tunning ?

Exhaust tunning means by arranging the exhaust pipes with suitable length and suitable valve timing to exhaust into the same pipe without disturbance.

When the exhaust valve of a diesel engine opens, the cylinder rapidly expands, and gain velocity and kinetic energy as they pass into the exhaust pipe.

The kinetic energy of the mass of exhaust gas carries it along the exhaust pipe, and causes a pressure build up ahead of the mass of gas and a partial vacuum behind it. This principle is used in a tuned exhaust system. The partial vacuum created by exhaust from one cylinder is used to help exhaust expulsion from the following cylinder.

Grouping of exhaust pipes depends upon the firing order, length & diameter of exhaust pipe.

Effect of inter cooling the charged air ?

. **Advantages**

The effect of cooling reduces the scavenge air temp and increase the density of air delivered to the cylinders, thus increasing the power out put delivered by the engine. It can increase the output by about 10%.

Cooled scavenge air reduces cylinder and exhaust gas temperature at a given power level and these temperatures thus remain within the acceptable limits.

Types of turbocharger L.O system ?

(a) Own sump and

(b) External L.O supply system

Ball type bearing (rolling type) are used in turbocharger – lube oil from the sumps on both air and exhaust sides is sprayed onto the bearing by means of attached rotor driven gear type pumps.

For sleeve type bearings are lubricated by external L.O supply system.

- ⇨ By gravity from independent header tank situated about six meters above the bearings. The tank capacity must supply for about 15 minutes after engine is stopped.
- ⇨ From a main L.O pump lead to the bearings with a separate L.O pipe line. It has also gravity tank incase of failure of L.O supply. (Under main engine L.O system)

Function of labyrinth seals ?

The bearings are separated from the blower and turbine by labyrinth seals. These seals are sealed by air supply from the discharge of blower to prevent oil entering the blower and to prevent contamination of the oil by the exhaust gas.

If be defect of labyrinth seals ?

At the blower side

Oil is leaked into the air system the cooling surfaces are covered with oil which are insulators and the cooling efficiency will be reduced.

Also there will be deposits on the blower and the blower efficiency will be reduced.

At turbine side

If the oil is leaked into the exhaust side there will be carbon deposits on the nozzle and turbine blades.

Reduce blower efficiency and fire in the exhaust piping. It will cause turbocharger surging.

Oil will contaminate with exhaust gas.

How will you know T/C air fitter chocked ?

It can be known by comparing the manometer difference. If manometer difference is greater than normal, T/C air fitter may choke.

It can cause - reduce engine power

- Black smoke will emit from the funnel

-scavenge pressure will reduce

Function of nozzle ring ?

To change pressure energy to velocity (kinetic energy)

Pulse system ?

This system makes full uses of higher pressure and temperature of the exhaust gas during blow down and rapidly opening of exhaust valve or ports the gas leaves from the cylinder at high velocity as pressure energy is effectively converted into kinetic energy to create a pressure wave or pulse in the exhaust pipe.

This pipe is so constructed in small diameter is quickly pressured and boosted up to form a pressure pulse.

The pulsating pressure waves reached up to the turbine and further expansion take place.

Buchi system –one type of pulse system used in 4 stroke engine.

What is labyrinth seal ?

It is a sealing ring which is sealed by air supply from the discharge of blower.

Functions

- ⇨ To prevent oil entering the blower
- ⇨ To prevent the contamination of the oil by the exhaust gas.

Purpose of inducer ?

To feed the shock less air flow to the impeller. (To guide the Air smoothly into the eye of Impeller)

Function of Diffuser

- ⇨ To direct the air smoothly into Volute Casing
- ⇨ Convert KE to PE of Inlet Air

What is K value ?

It is a distance between the rotor shaft end and the flange of bearing cover measured by blower side.

Purpose of K value ?

To ensure that rotating impeller does not to touch the stationary blower casing cover in case of thrust bearing worn out.

What will you do in case of TC failure ?

1) Rotor to be block
2) Exhaust gas to be by-passed the TC
3) Run engine with reduced speed with remaining TC
4) Use Auxiliary Blower
5) Maintain all temperature and pressure fuel, cooling water and lubrication within limit
6) Discuss with Captain for manoeuvring difficulties

Procedure for cutting of turbocharger ?

- When it is necessary to cut-off T/C due to heavy vibration, bearing failure, etc. cutting procedure should be done as per engine maker's instruction
- Cutting-off operation depends on number of T/C installed and number of T/C damaged
  1. Remove the nozzle ring
  2. Lock of the rotor shaft
  3. Blank off the blower discharge

Following procedures are in accordance with Sulzer RT engine practice

Case I: *Failure of one T/C, with Exhaust by-pass piping*

1) Lock rotor as per T/C manual
2) Remove blank flange in by-pass exhaust piping
3) Open covers of scavenge air trunk
4) Auxiliary blowers must be running during operation
5) If casing is cracked, stop T/C cooling
6) If T/C is supplied with external lubrication, shut L.O supply

Case II: *Failure of one T/C, of two T/C engine*

1) Lock rotor of damaged T/C
2) Remove expansion joints of both exhaust inlet and air outlet of damaged T/C and ppt blank flanges
3) If casing is cracked, stop T/C cooling
4) If T/C is supplied with external lubrication shut L.O supply
Output 15% RPM 50%

Case III: *Failure of all T/C of an engine, without Exhaust by-pass piping*

1) Lock rotors of all T/Cs
2) Open all covers of scavenge air trunk
3) Auxiliary blowers must be running during operation
4) If casing is cracked, stop T/C cooling
5) If T/C is supplied with external lubrication shut L.O supply
Output 15% RPM 50%

T/C out of order.
(One of two)
1. Rotor lock by locking device.
2. Insert orifice plate in compressor air outlet & inlet. (Small air flow to cool the impeller.(small gas flow to prevent condensation.)
3. Engine running with reduce speed & load with auxiliary blower running depending upon the engine running condition.

Only one T/C.
1. Rotor & nozzle ring remove.
2. Blanking plate are inserted.
3. Remove compensator, between compressor outlet & scavenge air duct.
4. Engine running with reduce speed & load with auxiliary blower running depending upon the engine running condition.

T/C out of order.(UHA discussion)

- **Rotor lock by locking device.**
- Insert orifice plate in compressor air outlet & inlet. (Small air flow to cool the impeller, small gas flow to prevent condensation.)
- Engine running with reduces speed & load with auxiliary blower running depending upon the engine running condition.

- **Rotor & nozzle ring remove.**
- Blanking plate are inserted.
- Remove compensator, between compressor outlet & scavenge air duct.
- Engine running with reduces speed & load with auxiliary blower running depending upon the engine running condition.

- If **exhaust gas by pass system** to turbocharger is available.
- Rotor lock by locking device.
- Blanking plates are inserted inlet and outlet of turbocharger. Use the exhaust gas by pass system.
- Engine running with reduces speed & load with auxiliary blower running depending upon the engine running condition.

Procedure for T/C O/H ?

- Lock off the engine staring mechanism.
- Remove the T/C air fitter.
- Drain off the oil from both drain plugs.
- Remove the bearing covers from both sides.
- Remove the locking wires.
- Unscrew the hexagon screws and remove oil suction pipes.
- Tighten again the hexagon screws of the bearing boxes.
- Check the deflection of the divergent nozzle by using pick tester and magnet stand.
- Remove the divergent nozzle by screw driver.
- Measure the K value at the blower side by using depth micrometer or caliper and straight edge.
- Lock the rotor with special tool.
- Extract the lubricating disc.
- Extract the both bearings by bearing extractor.

- The various parts should be warped in waxed paper to protect them against dirt and moisture.

T/C overhauling checking.

- Blade condition.
- Labyrinth seal.
- Bearing clearance. (a) 0.2 ~ 0.3 mm axial
- 0.15 ~ 0.2 mm radial
- Nozzle ring.
- After reassemble, check for balance & deflection.
- Check impeller & casing clearance. (K value)

What parts will you check when G/E T/C overhauled ?

- Check the deflection of divergent nozzle.
- Measure the K value at blower side.
- Change the bearing on both sides with the new one (because bearing service life is same as T/C overhauling time).
- Clean blower and turbine side with chemical and inspect carefully.
- Check the labyrinth seal.
- Made clear the labyrinth seal air line
- Check the casing for crack & wear
- Blade condition

After reassembled

- Check Static Balance
- Check Impeller and Casing clearance

When will you change TC Bearing ?

- As per Running Hour
- As per clearance
- When damaged
- When vibration is heavy

How to check deflection of divergent nozzle ?

By using **(1)** Pick tester &
(2) Magnet stand

What is the main purpose of T/C water washing ?

- To ensure efficient functioning of turbocharger.
- To protect the compressor and turbine from contamination (Deposits).

Disadvantages of T/C water washing to turbine side ?

- Engine speed has to lower.
- Thermal stress and corrosion usually occurred.
- Longer cleaning time.
- Very fine hard deposits and residues can not be removed easily with water washing.

Advantages of solid (crystal) cleaning ?

- Not required to reduce engine rpm, thus not effect on scheduled voyage
- No used of water, so no corrosion and thermal stress.

- Cleaning time is short.
- Not wear turbine blade.
- Effectively removed combustion residues and hard particle.

How will you carry out T/C turbine and blower side water washing ?

Blower side water washing

- ⇨ It can be done when M/E on full load.
- ⇨ Fill up the warm fresh water to hopper and closed the cover.
- ⇨ Open the valve and water will flow into the blower casing and mechanically attack the blower blades and clean the deposit.
- ⇨ Closed the valve, open the cover and check the cleaning water must be empty.

Turbine side water washing procedure

- ⇨ Turbine side water washing can be made with hot fresh water.
- ⇨ Inform to the bridge
- ⇨ Reduce the M/E rpm to recommended speed and T/C rpm.
- ⇨ Check the water washing injection nozzle if fitted. (directly aim to the exhaust grips before entering to the T/C)
- ⇨ Open T/C drain valve.
- ⇨ Open the water supply about 1 bar to turbine side.
- ⇨ Water washing must be made until the clean water coming out.
- ⇨ Closed the water supply and remove the nozzle.
- ⇨ Exhaust side drain can be closed after all water is drained out and dried.
- ⇨ Inform to the bridge and increase the M/E rpm gradually to sea speed.

The turbine side water washing is usually at departure after manoeuvring time.

For usual practice cleaning is done at every 500 hr, running hour depending on the cleanliness of the T/C.

Cereal Grains or Activated Charcoal particles cleaning of Turbine (Dry Cleaning)

1) Turbine side cleaning is superseded by coconut Charcoal particles, with grain size of 12 to 34 mesh
2) No speed reduction required and cleaning can be done at full speed, once every 240 hours
3) Compressed air of (3 -5 bar) us used to help the grains strike the deposited Turbine Blades and Nozzles, giving effective cleaning of hard particles
4) Air supply pipe is fitted to solid grain container, and grains are injected into exhaust system by air pressure, at the same point (as in water washing) just after exhaust grids
5) Turbine casing drain kept open during cleaning time of (about 2 minutes only) until drains become clear

When G/E T/C overhaul, what measurements do you taken ?

K value, it is a distance between the rotor shaft end and the flange of bearing cover measure at blower side (axial clearance).

Check radial clearance (at plane bearing), by placing clock gauge on the shaft from the top and clamp by screw driver from bottom, record the clearance.

Rotor and Casing clearance (for new casing or new rotor) (L & M values)

How to measure TC axial and radial clearance ?

Axial Clearance : Push the shaft by screw jack and measure by Depth Gauge (0.2 – 0.3 mm)

Radial Clearance : Lift the shaft radially and measure by Dial Gauge (0.15 - .02 mm)

Why T/C exhaust outlet lower than inlet temperature ?

Some exhaust gas heat & pressure energy is transferred to mechanical rotating energy, thus pressure become decrease and temperature lower.

What will occur is oil leak in T/C system ?

- ⇨ If oil is leaked into the air system the cooling surface are covered with oil which are insulated & cooling efficiency will be reduce (ie. Scavenge temp: drop ; Exht: temp: high)
- ⇨ Also there will be deposits on the blow and blower efficiency will be reduced
- ⇨ If oil leaked into exhaust side, Carbon deposits on the nozzle & turbine blade. It cause surging, reduces blowers efficiency and fire in the exhaust piping (uptake fire)

TC over run

Causes:

- ⇨ Happened in constant pressure turbo-charged engine
- ⇨ Caused due to fire and /or detonation of scavenge space
- ⇨ Exhaust trunk fire due to accumulation of leaked or excess LO and unburned fuel

Effects:

- ⇨ TC bearings, casing damaged
- ⇨ ER fire

Prevention:

- ⇨ Scavenge space regular cleaning
- ⇨ Exhaust gas pipe regular cleaning
- ⇨ Maintain complete combustion of fuel
- ⇨ Liner, piston and rings, fuel vales, cylinder lubrication, maintained in good order
- ⇨ Avoid operating ME under reduced load for long term

TC Vibration

- ⇨ Unbalanced
- ⇨ Bearing defects
- ⇨ Deposits in nozzle ring
- ⇨ Impingement
- ⇨ Surging, Scavenge Fire, Overloading

TC Balancing

- ⇨ Static balance
- ⇨ Dynamic balance

FUEL PUMP

Function of fuel injection pump

To supply accurate metering amount of fuel with sufficient pressure to open fuel injector in correct timing.

How to fuel cut out (Individually)

- Reduce the engine speed
- By lifting the pump roller form cam peak and securing the pump roller guide
- By making pump rack to zero position

How to notice the incorrect timing ?

- Difficult to start the engine
- Abnormal exhaust temperature reading
- Black smoke coming out
- Irregular running of engine.

How to check the fuel injection pump timing ?

- Lock off the starring mechanism
- Start L.O pump
- Open all indicator cock

By hair line method-

Turn the engine so that the unit to be check is toward the TDC of compression stroke (plunger upstroke) so that hair line on plunger & pump body are coincided.

When hair lines are coincided, stopped turning and check the mark on the fly wheel whether timing is correct or not.

In hair line not given-

Take out fuel in/out pipe on pump (by removing binjo bolt)

By using hand torch & mirror on each side

Turn the engine so that the unit to be check is toward the TDC of compression (at plunger upstroke) so that the light on mirror is disappearing (ie torch light has gone on mirror)

AT this time, stopped engine turning & check the mark on flywheel.

By Goose net method

Turn the engine so that No.1 piston is at the top dead centre position at the beginning of the firing stroke

Turn the engine backwards to a point which is a little earlier than the fuel injection point.

Shut fuel oil supply and remove delivery valve assembly with delivery pipe to fuel valve of No. 1 unit and put on a bent pipe in place of the delivery pipe on the pump discharge.

Fuel supply valve to the engine is to be opened and put the fuel lever to running position. Fuel oil will flow out from the bent pipe.

Turn the engine towards the TDC in its running direction slowly until fuel cease to flow and check the marks on the flywheel whether the timing position is correct or not;

Adjustment

Small engine

- Slightly different variation can be adjusted-

- By adding or reduction shims on the pump base, or
- By turning the plunger up and down adjustment screw on the pump roller guide, or
- By shifting the coupling flange between the pump and the drive side of the engine in case of combined unit system, (for small engine)

Large engine

- The timing can be altered by shifting the camshaft to the position relative to the crankshaft (after removing the idler gear between the crankshaft and the camshaft.) For large engine
- For adjustable cam type engines timing can be altered by individual cams of the fuel pumps.

Remark

- Individual unit timing checking up & adjustment required for movable cam type engine
- For solid camshaft type, it is only required for checking on No. 1 unit.

If no TDC mark on flywheel, How will you check pump timing?

IN M/E

1) Make a marking between cross head and guide Shoe while they are before TDC and also mark at the flywheel.
2) Turn the crank shaft in the same direction until the crosshead and guide shoe are at the previous mark (coincide)
3) Make the second marking on the fly wheel. We got two marks on the flywheel mid point between the two points is TDC.
4) I will divide 360C around the flywheel.

IN G/E

1) Remove the fuel valve
2) Insert the rod onto the piston (mark on rod and flywheel)
3) Turn crank until the rod previous mark
4) Make the second marking on the fly wheel
5) Mid point between the two points is TDC

What points do you check on fuel pump when overhaul or how will you decide ?

- Check plunger guide wear & tear
- Check spring (length & stiffness, crack)
- Plunger & barrel wear & tear, check clearance (5 micro for DO, 15 micro for HO) by dropping the plunger into the barrel it fall down slowly is OK
- Check control sleeve and rack for crack
- Check the Delivery valve face
- Check 'O' ring of fitted.

METERING OF FUEL

Controlling the fuel amount in two ways, by means of a helix groove on the plunger or by means of control valves. for effective stroke.

The quantity of fuel delivered is regulated by the vertical length of the helix where it is in line with the suction port. This setting may be altered by rotating the plunger. In stop position, ***the vertical slot of the plunger is in lined with the spill port*** where then ports are opened and thus no injection occurred.

VIT system.

The VIT mechanism automatically change the injection timing according to the load to maximum combustion pressure at the engine load between 85 ~ 100%.
Advantage - Fuel save about 1.5 gm/kw-hr @ 85% load.
- Maximum combustion at its normal maximum value.

AP MOOLER GEK QUESTION

1) EMERGENCY

BLACK OUT –How do you make the procedure to restore if going to black out in your ship?

E/R FLOOD – How do you take action when ER flooded? (in sequences)

2) –Preparations for before arrival manoeuvring

_Preparations for before departure

3) GENERATOR

What are these do you check on main switch board when G/ E is running?

Is your G/E capacity is sufficient with the incoming load?

If not in sufficient how do make in action ?

How many G/E do you run when to be recovery required load?

4) ELECTRICAL

-How do you check the condition of the motor?

-Besides the insulation test for meter reading how can check the motor if it is not in running?

-Besides the physical damage what is wrong the insulation shorted in winding?

-What points do you check in running motor?

PSYCHO TEST - Chosen wards, you are expected by others and expected by your self. (Time – unlimited)

I.Q TEST -50-Questions (Time- 15 minutes)

(INYA LAKE HOTEL 26-11-02)

CYLINDER LINERS

Function

The compression of air and the combustion of fuel/air mixture take place inside the cylinder liner, so it forms part of the combustion chamber.

Cylinder liner wear

Normal frictional wear : Due to metal-to-metal contact with very high surface asperities under marginal lubrication condition.

Abrasive wear : Due to presence of hard foreign particles from Air, fuel and lub oil

Corrosive wear : Due to H_2SO_4acid attack owing to products of combustion. Sulphur within a fuel. Only about 0.1% of the Sulphur in the fuel causes corrosive wear, like hot and cold corrosion, and the remainder escapes with exhaust gases.

Due to Hydrochloric acid attack because of salts in air, charge air cooler leakage, sea water in fuels and lube oils.

Causes of liner wear

(A). Improper running-in-during first few hours, 10 to 20 hours, the piston rings have to form an effective seal against the passage of destructive blow by gases. Surfaces of rings and liner slide freely against one another without the asperities welding together when engine is under load. Metallurgical changes take place on the metal surfaces during the initial running- in that a thick work hardened layer is formed, which has good anti-wear properties in subsequent operation.

(B). Misalignment of piston, or distortion of liner, preventing bedding-in of piston and liner.

(C). Inadequate oil supply or unsatisfactory arrangement of cylinder lubrication.

(D). Lube oil is too low in viscosity or too low in alkalinity (Grade of cylinder oils).

(E). Incorrect piston rings clearances.

(F). Unsuitable liner material (quality).

(G). Unsuitable piston and ring materials.

(H). Contamination of lube oil by abrasive materials.

(I). Cylinder wall temperature too high or too low.

(J). Engine overload.

(K). Scavenging air temperature too low, resulting in excessive quantities of condensed water entering the cylinder (leading to dew point corrosion).

(L). Inefficient combustion, promoting deposits formation and degradation of the lube oil.

(M). Use of low Sulphur fuel oil in conjunction with high (TBN) alkalinity lubes oil.

Causes of cylinder liner wear.

1) Improper running in.(10 to 20 hours)
2) Misalignment of piston or distorted liner.
3) Inadequate oil supply or unsatisfactory arrangement of cylinder lubrication.
4) Cyl oil is too low in viscosity or too low in alkalinity.
5) Incorrect piston ring clearance.
6) Unsuitable liner material.
7) Contamination of cyl oil by abrasive materials.
8) Engine over load.

9) Scavenge air temperature too low.
10) Insufficient combustion.
11) Use of low sulphur fuel oil in conjunction with high alkalinity lube oil.

Types of wear

Scratching: Small Scratch may develop in the region of ring travel due to small particles entrapped between the bore and rings. Those particles originated from the machined surfaces of the mating pair.

Scoring:

Score confined to the region of ring travel and may extend to the region swept by the piston. Scoring being developed from Scratching and the origins is similar to Scratching.

Scuffing:

Scuffing is a condition develops in the ring travel on the thrust side of the liner and depends on the efficiency of the Lubrication, speed and Loading.

Clover leaf pattern:

Some liners wears irregular ovality patterns but some gives "Clover-Leafing" pattern of longitudinal corrosive wear at several points around the liner concentrated between the lubrication orifices.

The cause is owing to combined effects of incorrect feed rate of cylinder oils (inadequate) and acidic effect of combustion products (or low TBN lube oil). The wear concentrated between the points of lube oil quills.

- In actual practice, wear *never takes place concentrically*, and it depends on *heel and trim* of the ship in service, and effective *guide clearance*
- In tankers and bulk carriers, where long *ballast passage* are made with the trim aft, *Maximum wear* will be in the *fore and aft plane,* and especially *on aft side* of the liner.

WEAR RATE

- Liner wear rate is high during the running in period after which it will come to *a uniform* wear rate within most of its service life.
- Finality the wear rate *increases* as wear becomes *excessive and rapidly* due to difficulties in maintaining the rings gas tight.
- *Wear rate can be high* about 0.75mm/1000 has in *large slow speed engines* using residual fuel oils which contain in excess of 1.5% of Sulphur
- *Wear rate being lower* about 0.02 mm/1000 hrs *in medium speed engines*, due to burning low Sulphur fuel oils.
- When the Vanadium is added during manufacturing, the wear rate could be significantly reduced to 0.025mm-0.50mm/1000 hrs.
- Maximum wear allowance of liner = 0.7% to 1% of original bore for large output engines

WEAR PATTERN

- Maximum liner wear is *at the upper limit of the travel* of the top compression rings at the top of the stroke
- This *reduces* towards the lower end of the stroke but will *increase* in way of exhaust and scavenge ports.

Reasons for maximum wear at top of the stroke being:

(01) The gas *load* behind the ring is *maximum*
(02) It is the *hottest* region
(03) Viscosity of oil film is low and *liable to breakdown* under heavy load and high temperature
(04) Abrupt *Change in direction of piston rings*, at dead ends of reciprocating motion.
(05) Corrosive wear
(06) More liable to be attacked by acids.

Reason of maximum wear around the ports.

Due to leakage of hot gases past the top ring into the ports and these hot gases will tend to burn off the oil film.

How to maintain minimum liner wear ?

(01) By use of good quality cylinder oils with detergent additives of proper TBN valve.
(02) By use of corrosion resistant liner materials with some proper percentage of Vanadium, Titanium, Chromium and chrome plated liners.
(03) By maintaining good Fuel injection condition (efficient cleaning of F.O, Correct F.O temp:, Correct F.O grade)
(04) By maintaining Jacket, water temperature as high as practical to avoid dew point condensation of acid products.
(05) By maintaining proper feed rate of cylinder oils.

Points to remember:

(1) Lubricator timing
(2) Position of quills
(3) Oil feed rate
(4) Oil refreshing rates
(5) Oil film thickness
(6) Engine load

Sign of liner crack

(01) Fluctuation of pressure and temperature of jacket C.W system
(02) F.W coming out from the scavenge drains
(03) Overload at that particular unit (high in exht: temp: and Jacket temp)
(04) Expansion tank foaming

CAUSES

(01) Due to rapid contraction of metal
(02) High difference in Jacket water (working) temperature
(03) Insufficient cooling
(04) Over tightening of cylinder head bolts
(05) Design failure
(06) After effect of immense Scavenge fire
(07) Due to loosened out foundation chocks resulting tie bolt slackening and Hoop Stresses on Cylinder liner increases
(08) Due to very high injection viscosity

Cause of cylinder liner crack.

1. Excessive thermal & mechanical load.
2. Poor material & design.
3. Piston seizure.
4. Localized scavenge fire.
6. Over or Uneven tightening of cylinder cover nut.
7. In loop & cross scavenging, high temperature gradient.
8. Water side corrosion reduce liner strength.

PREVENTION

(01) Use torque spanner
(02) Maintain C.W temp: at a level within a limit
(03) Close watch on temp: and press: of gases, Fuel oils and C.W ETC…
(04) Renew cylinder liner when worn down beyond limit about 0.7% more than original bore.

Consequence of excessive liner & piston ring wear

1) Blow pass occur & scavenge fire can occur
2) Blow pass occur & crankcase explosion can occur
3) Over heat on liner & liner crack & piston seizure & piston breakage may occur
4) Engine become unbalance & power loss
5) Turbocharger surging may occur

Removing and refitting the liner

Before removing

1) Immobilisation permit taken from port authority
2) Vessel in upright position
3) Lifting gears and tools in good working order
4) All spares are ready.
5) Persons grouped for assigned jobs.

Removing the liner

1) Drain CW from cylinder jacket
2) All lubricator quills removed
3) Cylinder cover, piston and stuffing box removed in usual way
4) Cover the piston rod stuffing box seating with special cover
5) If liner is to be reused, liner wear should be measured and recorded
6) Position of liner, relative to cylinder jacket, properly marked
7) CW outlet pieces to cylinder cover removed
8) Attach the liner withdrawing tool as per instruction, and tighten the upper nut until liner comes in contact with upper supporting bar [strong back bar]
9) With overhead crane and sling arrangement, liner is drawn out

Before refitting

01) *If old liner i*s to be reused, clean thoroughly
02) Landing surface of quills checked for damage and carbon deposits on oil holes cleaned.
03) Rubber sealing ring groves, cleaned with old round file until to bare metal
04) Surface inside jacket, coated with anti-corrosive paint, and sitting surfaces cleaned.
05) Sharp edges inside jacket, chamfered slightly to prevent cutting rubber sealing rings.
06) *If new liner* is to be fitted, gauged before fitting

07) New liner is to be lowered down into position, without sealing rings fitted, to ensure it is correct size. Liner should not only drop freely by its own weight, but there should be slight radial clearance between liner and jacket to allow for expansion.
08) Radial clearance at lower end, < 0.2 mm for 750 bore liner
09) Radial clearance at top, < 0.001 mm/mm of liner bore.
10) Rubber sealing rings should grip firmly around liner, and a 10% stretch would be adequate
11) If there is no original reference mark on liner, quills should be fitted and mark the correct position of liner relative to cylinder jacket.
12) Remove the liner again and sealing rings fitted.

Refitting liner

1) Soft soap or similar lubricant to be applied to rubber sealing rings for easy fitting
2) Fit in correct position as per instruction
3) New liner re-gauged after final landing to check any distortion and recorded
4) Refit quills and test lubrication. All parts refitted in usual way
5) Fill cylinder jacket and check water-tightness under pressure.

Running in During the first 10~20 hours

1) Cylinder oil feed rate at maximum
2) Engine load reduced
3) Reduce oil feed rate to normal and increase the load stepwise
4) Liner checked from inspection door and scavenge space, at first opportunity

Fitting cylinder liner

1) Clean close fitting parts, L.O fittings, rubber sealing ring grooves.
2) Clean inside the jacket and coated with anti corrosive paint.
3) Chamfered slightly sharp edges inside the jacket.
4) Soft soap or similar lubricant apply to rubber ring and fitting surfaces.
5) For new liner first lowered into position without fitting rubber ring to check the fitting clearance and fitting of cylinder lubricator.

MARINE POLLUTION PREVENTION

Why fitted the O.W.S ?

Oil/water separator are used to ensure that ships do not discharge oil when pumping out bilges, oil tanks or any oil contaminated space, according to the regulation on marine oil pollution prevention 73/78.

Requirement of O.W.S

01. Oily water separators for bilge and ballast applications should be capable of giving an affluent containing less than 100 ppm of oil irrespective of the oil content of the feed supplied to the equipment.

02. Filtering system are further required to provide and effluent of not more than 15 ppm under all inlet conditions.

Safety device on O.W.S

Pressure relief valve on discharge pipe
O.D.M system with high ppm alarm and automatic pump stopping device.
Test cock (level), drain valve

What do you when alarm is on ?

Open the oil drain cocks and check the oil control level
Stop the pump

How will you pump out oily bilge overboard O.W.S discharge regulation ?

Regulations controlling the Pollution by Operational Discharge

Oily bilges are prohibited from discharge into the sea except the following conditions.

Cargo slops	**Machinery space / Ballast tanks Discharge**	
	Outside Special Area	**Within Special Areas**
▪ Outside S.A ▪ More than 50 NM from land ▪ Vessel en-route ▪ Instantaneous rate less than 30 litres per NM ▪ Total 1/30000 of cargo ▪ Operating oil separator, slop tank ODM.	▪ Vessel enroute ▪ Has in operation oil discharge monitoring system, oily water separator ▪ Oil particle less than 15 ppm	▪ Vessel en route ▪ Has in operation oil filtering equipment with automatic stopping device ▪ Oil particles less than 15 ppm

Special Area

1) Black Sea, **2)** Red Sea, **3)** Mediterranean Sea, **4)** Persian Gulf Area ,**5)** Gulf of Aden, **6)** Antarctic Sea, **7)** North Sea, **8)** Wider Caribbean Sea, **9)** Baltic Sea,

How will you discharge bilge ? *****

- Take C/E permission to discharge Oily Bilge through O.W.S
- If ship is outside special area, Vessel must be enroute , oily bilge are discharged through O.W.S with ODM system , oil particle less than 15 ppm.
- If ship is within special area , vessel must be enroute, oily bilge are discharge d through il filtering equipment with automatic stopping device, oil particle less than 15 ppm
- After operation, discharge quantity, time and location to be put in oil record book.

What is the bilge injection ?

It is emergency bilge suction lead to main sea water pump suction line, commonly called the bilge injection. This valve is of screw lift screw down type. No mud box or strainer this line.

It can be used in case of E/R flood & in case of emergency

Action of bilge flooded

At Sea : Use direct bilge, Bilge injection valve only flooded with dangerous condition

In port : Put into bilge tank if not capable sends to the shore

Bilge system requirement

1) Bilge system to be entirely separate from other system
2) Main bilge is connected two bilge pumps, direct bilge suction are fitted on each side of machinery space (P & S)
3) Emergency bilge suction lead to main cooling S.W pump suction line. Fitting mud box or strum box should be avoided.
4) Direct bilge suctions in the machinery space and tunnel, mud boxes fitted at platform level, easily accessible cleaning.
5) The bilge pump are self priming or capable of being quickly primed
6) Each suction is fitted a screw down non return valve in order to prevent inter communication
7) is fitted to the discharge side of the bilge pump (to prevent the discharge oil overboard)

Attachment of O.W.S

- Photo copy of MARPOL certificate
- Original oil disposal to shore certificate
- Dirty oil and sludge piping diagram
- USCG warning

How do you operate the O.W.S ? *******

- Take the permission form C/E
- Close the drain valve; open up all necessary valves on the system.
- Run pump, first taking suction from sea chest to fill up the separator with sea water keeping an eye on the shell pressure
- Open all vents and cocks to release air from separator.
- Switch on the ODM and alarm system
- Open steam heater valves and maintain the temperature about 60 °C
- Flush the oil content meter with fresh water for at least 5 minutes before putting the monitor operation. Then change over from fresh water to sampling line.
- Change over pump suction to draw from bilge tank.

During operation, regular checking of water oil interface through test cocks.

If lower test cock comes out oil, open the drain valve until upper test cock come out water & shut oil valve

After operation, flush the system with sea water & flush oil content meter with Fresh water then bilge discharge amount & time & ship location to be put in O.R.B.

Why O.D.M is fitted at O.W.S ?

To monitor the oil content in the discharge water from O.W.S and to give warning.

How to test ODM ?

Disconnect the sample pipe
Switch on the ODM system
Inject the oil into sample line by opening sample line valve
Alarm will operate

What is the coalescer ? Its function ?

Coalescer is the fitter element fitted at the oily water separator system made of steel wire mesh or Nylon fibres.
Its function is to coalesce tiny remaining oil particles to from a large drop (size) of oil.

ODM operation

A sample of the effluent is passed through a vertical cylinder, and receives energy emitted from an ultra violet lamp at the top of the cylinder. The energy emitted due to any fluorescence is monitored by a photoelectric cell, which produces a signal dependent on the amount of oil, present in the sample.

In the event of excess oil contents, this signal operates the diverting valve and the separator discharge is diverted to the slop tank instead of discharging overboard.

Maintenance to O.W.S

1) Routine attention is needed to obtain satisfactory performance
2) Obey the maker instructions.
3) Removed of internal contaminant
4) The prevention of corrosion by removal of sludge
5) Check for places where anti corrosion coating had deteriorated & apply anti-corrosive painting
6) Preservation of bilge pump
7) If coalescer is disposal checked & renewed
8) If coalescer is renewable checked and cleaned
9) Checked & test the ODM
10) Oil sensor probe must be cleaned
11) Cleaned & coated to catch plate
12) All test cock line clear

Instruction for oily water separator. (As a C/E)

1. Inform to C/E. C/E select the position after taking the ship position from the bridge.
2. Operation.
3. Regulation.

In port not allow.

Regulation

Outside special area	Within special area
1. Vessel enroute. 2. Oil particle less than 15 ppm. 3. Has an operational oil discharge monitoring system and alarm system.	1. Vessel enroute. 2. Oil particle less than 15 ppm. 3. Has an operational oil discharge monitoring system and alarm system and 15 ppm stopping device.

- Bilge overboard discharge valve must be tight close and kept under chain and lock and bilge connection must be blanked by Blind Flange. This connection must be absolutely free from oil and sludge.
- Bilge tank must be make ready and transfer to the bilge tank.
- Minimize the oil leakage control the increasing of machinery space bilge water.

Environmental Pollution Prevention

What is sewage ?

- ☞ Drainage and wastes from toilets, but not including wash water form basins, and wash tubs.
- ☞ All drainage from medical premises, including wash water from basins and wash tubs.
- ☞ Drainage from spaces containing living animals.

Emission of Black Smoke

Black smoke from ship may lead to pollution of air space, and many countries have their own regulations that are not to be violated. Smoke from ship is checked for blackness; by comparing with Ringelman Scale Chart. On this scale, white card is numbered '0' and totally black card is '5'.

There is specific time limit, during which black smoke emission is not penalised.

The allowable black smoke emissions are:

1) Continuous emission must not be longer than 4 minutes
2) Short emission in every 20 minutes period, must be limited to 3 minutes.
3) Another part of ruling limits, emission must be not more than10 minutes in any 2 hour periods.

BIOLOGICAL (AEROBIC) SEWAGE TREATMENT PLANT

1) The unit is divided into three compartments, the aeration Chamber, Settling Chamber and Chlorinator.
2) Sewage enters Aeration tank, through soil inlet retained for about 24 hours being thoroughly mixed and aerated by the aerators located at the bottom of the tank.
3) The aerobic bacteria and micro organisms break down the organic wastes and produce new bacteria cells and organisms.
4) Air, which provides the oxygen for bacteria and micro organisms, is supplied by a rotary blower to the aerators
5) The mixture is replaced by incoming sewage into Settling Tank, after passing through coarse screen
6) All solids are precipitated in Settling Tank as activated sludge which is then returned by air lift back to the aeration tank where it is mixed with the incoming raw sewage.
7) Clean liquid is displaced into the chlorinator, where remaining bacteria are killed.
8) Discharge of harmless effluent is controlled by float switch connected to the discharge pump.

Important Equipment

1) Two Rotary Blowers
2) Two Discharge Pumps
3) Safety Valve at Aeration Blower
4) High water level activating switch
5) Low water level activating switch
6) High water level alarm

Biochemical Oxygen Demand, BOD

Amount of Oxygen taken up by *Bacteria Incubation Process*, in PPM

Coliform Count

1) Coliform is the name given to bacteria group, found in intestine

2) Not normally harmful, but can cause Dysentery, Typhoid, and Gastro-enteritis.

3) Coliform Count checks effectiveness of disinfection

4) Carried-out on effluent sample and incubating it for 24 – 48 hours at 35 °C

5) Colliform Bacteria count: 200 / 100 mlt. [Maximum]

Regulation controlling Sewage Discharge

Type of sewage	Distance in NM from nearest land		
	0	**4**	**12**
Sewage treated by approved Sewage treatment plant	No visible floating solids or discoloration		
Sewage comminuted and disinfected with approved equipment	Prohibited		
Untreated sewage	Prohibited		
Sewage held in holding tanks	Prohibited		Moderate rate, ship en-route at not less than 4 knots.

Annex V

Garbage type	Outside special Areas	In special area
Plastic – includes synthetic ropes, fishing nets and plastic garbage bags	Disposal prohibited	Disposal prohibited
Floating dunnage, lining and packing materials	> 25 miles of shore	Disposal prohibited
Paper, rags, glass, metal bottles, crockery and similar refuse	> 12 miles	Disposal prohibited
All other garbage including paper, rags, glass comminuted or ground	> 3 miles	Disposal prohibited
Food waste not comminuted or ground	> 12 miles	>12 miles

Comminuted or ground garbage must be able to pass through a screen with mesh size no larger than 25 mm. Garbage disposal regulations for special areas shall take effect in accordance with regulation 5 (4)(b) Annex V

INCINERATOR

What is incinerator ?

It is a waste disposal burning until which will burn solid material and all types of waste oil. It is fitted to prevent pollution of sea.

Safety System

1) The safety devices shut down the unit and give out alarms:
- **a.** When the pilot and main burner fail to operate
- **b.** When the flue gas temperature reaches above 400'C
- **c.** When the cooling fan fails to operate

2) Emergency fuel shutdown valve

3) Micro switch, fitted to hinged furnace door (Interlock)

Burning capacity of incinerator

It is mentioned at the supplementary of IOPP Certificate, and the incinerator should burn:

1) Waste oil

2) Oil and water mixture up to 25% of water content

3) Rag and galley waste

4) Solid matters from sewage plant

Function of cooling fan

1) To cool and protect incinerator shell from overheating

2) To keep the combustion chamber at a negative pressure

3) To keep the flue gas temperature below a safety limit

Action when sludge too much ***** How will you control the sludge on board ?

At sea : incinerated by waste oil incinerator after getting C/E permission and put the incinerated amount in oil record book after incinerated them

In port : Send to shore; get the received letter form shore authority

How to incinerate the waste oil ?

01) Get C/E permission

02) Give heating to waste oil service tank about 60C

03) During heating drain out the water at drain valve

04) After heating start the agitator to agitate the sludge mix some D.O if necessary

05) Start the fan to purge the furnace at least 1 min

06) Open the D.O tank valve

07) Adjust the fuel air ratio of burner

08) Light up the pilot burner with aids of spark igniter

09) Flame burns at pilot burner – start the main burner and check flame

10) When the flame is stable – open the waste oil valve, close the D.O valve
(D.O valve crack open if necessary)

11) Enter to the engine log book and oil record book amount of incinerated oil, position and time.

Sludge tank requirements

1) Capacity must be minimum 1 % of used HFO for 30 days (or)
½% of used DO for 30 days

2) Sufficient *manholes* to reach all parts of tank

3) Adequate *heating* arrangement

4) *No direct connection* between sludge tank discharge piping and *overboard* discharge piping

5) Fitted with designated *pump*, having suitable capacity and discharge head

6) Fitted with standard discharge connection (*International Discharge Connection*)

7) Fitted with *high level alarm*

Sludge Tank Capacity

For ship, which does not carry ballast water in oil fuel tank, minimum sludge tank capacity should be calculated as:

$$\mathbf{V = KCD}\ m^3$$

Where K = 0.01 for ship, where HO is purified for ME (i.e. 1%)
K = 0.005 for ships using DO or HO which does not require purification before use (i.e. ½%
C = Daily fuel oil consumption
D = Maximum period of voyage between posts (in days)
In absence of precise data, a figure of 30 days should be used.

Note: Sludge Tank Capacity (min) = 1 % of used HFO for 30 days (or)
½% of used DO for 30 days

PISTON

Function

Piston forms the lower part of the combustion chamber. It seals the cylinder and transmits the gas pressure to the crankshaft through connecting rod. The piston absorbs heat of combustion and this heat must be conducted away if the metal temperature is to be kept in safe limits.

Causes of Cracks of Piston Crown

Cranks, in star pattern on the crown, mainly happen owing to thermal and mechanical stresses may be either of the following faults:

(01) Unsuitable material or inadequate matching for a rating of engine.
(02) Excessive scales on cooling gallery
(03) Cavitations erosion
(04) High coolant temperature
(05) Local impingement
(06) High water content in fuel
(07) Poor atomization, High penetration of fuel

Causes of piston crown burning

a) *Heavy deposits inside cooling gallery causing* overheating of piston.
b) Faulty fuel valves allowing fuel impingement on the crown owing to *incorrect spray angle.*
c) *Too high injection viscosity* causing *over penetration and impingement* on the crown then surface ignition will occur.
d) Fuel containing *excessive amount of water* also may cause impingement attack on crown.
e) High coolant temperature
f) *Late and incomplete combustion*

Remedial actions against burning away

When the piston crown burns down the following checks to be made:

- Fuel system **:** heating temperature, kinds of fuel, pureness of fuel, standard of maintenance of fuel pump and fuel valve. Reduce water contents in F.O (be sure purification), fuel injection timing must actuate
- High load **:**overload or over-torque during adverse weather
- Lowering of cooling effect **:** abnormality in cooling passage, degree of pureness of cooling medium, deposits on under crown area and preventive control for corrosion.(regular test and treatment of C.F.W must carried out)
- Lack of air **:**dirty scavenge air and exhaust gas system

The additional countermeasures to be taken are:

- Proper selection of material
- Higher rate of cooling
- Proper surface treatment
- Installation of jet cooling system to the cooling side of the crown

- If when the wear deeper than (6.0 mm/ 11.0 mm/ 12.0 mm) or 30% to 50% of the crown thickness, Build-up welding of special alloy steel (INCONEL) to the flame side of the crown can be introduced along with proper heat treatments.
- In case where only light burnt off positions are ingrained, grinding or filing them down and smoothing out the sharp edge zones with emery cloth will be sufficient.

Caused of Piston Overheated

It may be due either to:

(01) Inadequate or failure of coolant supply and excessive deposit in cooling gallery.
(02) Continued overload operation
(03) Unbalanced cylinder load
(04) Incomplete combustion owing to loss of compression, faulty fuel timing, unstable fuel and insufficient charge air.
(05) High friction on liner owing to failure of lubrication, faulty rings conditions, long skirt touching the liner due Misalignment of piston and distorted liner
(06) Late ignition faulty fuel timing
(07) Excessive water content in fuel.
(08) Faulty rings conditions causing blow-by
(09) Long skirt touching the liner due Misalignment of piston and distorted liner
(10) Excessive deposit in cooling gallary

Piston crown wear, burn

- ⇨ Clean the piston crown
- ⇨ Check the crown wear by means of template (maker supply wear down gauge[template]) & feeler
- ⇨ The permissible burn away is shown on maker supply wear down gauge.

Measurement at unit overhaul unit survey

- Liner calibration (maximum wear 0.75 % to 1.0 %of bore dia)
- Piston crown wear & ring groove
- Piston ring gap clearance (0.2 % to 0.5 % of bore diameter, maximum allowance is 3 times the original
- Piston ring vertical clearance (0.2 to 0.25 mm)
- Piston ring radial thickness (1/30 of bore diameter)
- Stuffing box sealing & scraper ring gap clearance (6 mm at each gap)

Trunk engine piston seizure

1) Blocked coolant supply to piston
2) Overheating of the unit
3) Exhaust valve damaged
4) Rings damaged

How to pressure test when piston overhaul ?

- After cleaning the piston, externally and internally reassemble the piston will new two synthetic rubbers ‘O’ ring.
- Invert the piston crown on the platform
- Fill L.O into the oil outlet pipe of the piston rod until oil is fully to outlet and inlet pipe.

- Fit the piston rod with special test flange which consist of the connection pipe
- Connect the hydraulic pump to the connection pipe of the flange after air is purged out
- Apply the pressure 1.5 times the working pressure for more than 10 minutes
- Check L.O leakage between piston crown and piston skirt, piston skirt and piston rod.

The piston seizure may due to:
01) Blocked coolant supply to piston
02) Over fuelling of the unit
03) Valve damage
04) Ring damage
05) Faulty timing
06) Cylinder lubrication failure

Piston

Function of Piston

- Piston forms part of combustion chamber.
- Piston converts gas force to mechanical power by reciprocating motion
- Shape of piston is governed by combustion chamber
- **In Trunk Type engine:** Piston skirts take up the side thrust due to connecting rod angularity and guide the whole piston in the liner.
- **In Cross Head Type Engine:** The side thrust due to connecting rod angularity is not on the liner. The side thrust is taken up by the guide and guide shoe

Constructional Feature of Piston

Composite pistons are made in two parts and used in highly rated slow and medium speed engines.

⇨ Crown : Top part of piston
⇨ Skirt : Bottom part of piston

Crown

- Concave or convex shape external contour
- Concave crown is suitable for proper combustion
- Convex crown is suitable for high mechanical stress due to thick material
- Thin crown is for low thermal stress.
- Tapered on top of piston ring to allow for thermal expansion.
- Subjected to high mechanical and thermal stresses.
- Carries compression rings in the grooves
- Heat resistance material e.g. **Cr-Mo Steel** / **Alloy Steel** used for highly rated engines
- Extensive cooling is essential for piston crown
- Modern engines are made of thick crown with 'Bore' cooling & lub oil cooled.

Skirt

- Takes up side thrust due to connecting rod angularity (trunk type engine)
- Guides piston in the liner and prevents rocking
- Accommodates oil scraper ring in the groves
- Provided with wearing ring in some design
- Made of wear resistant & low co-efficient of expansion material e.g. Cast Iron

Crown Thickness Considerations

- Higher strength & heat resistance properties of material
- Rigidity to withstand thermal & mechanical loading without distortion
- Mass to be controlled to limit inertia forces and should have heat dissipation capacity

Properties of Crown Material

- Higher mechanical strength and higher fatigue strength
- High thermal conductivity and high creep resistance property
- High surface property i.e. hardness, anti-corrosive
- Low co-efficient of expansion

Crown Cooling Passage Design

- Boring of cooling passage closer to combustion chamber surface
- Cooling passage to cover optimum surface are to maintain piston temperature within safe limit.
- Cooling passage design should be such to prevent formation of vapour pockets, sludge & choking.
- To maintain designed flow rate of coolant.

Piston Cooling Design

- It should be capable of lub oil splash by a jet from top of connecting rod.
- Should have chambers & passages in the crown through which coolant is conducted
- In some design ducts run full, and passages are of small sectional area to obtain high coolant velocity
- Other designs use large chambers to operate coolant partially full and to promote violent splashing due to piston motion termed as **cocktail shaker** design.

Cooling of Piston

Heat transfer takes place following means-

- To liner jacket cooling through piston rings
- Oil sprayed on the inner surface from c/c by rotating cranks & bearing
- Coolant is circulated through cooling passages in the piston

Cooling & Coolant : Oil ⇨ Specific Heat 2 temperature 10°C

: Water ⇨ Specific Heat 4 temperature 14°C

For same cooling effect, the amount of cooling oil circulation is 2.8 Times the amount of water
Modern Large Engines use Oil Cooled Piston

Cooling Flow Pattern

- Coolant enters at the lowest part of the cooling space & leaves from the upper most part.
- Upward movement of the coolant is uniform on opposite sides of the piston to prevent distortion.
- The flow direction is in such a manner that the piston is always full of coolant and the underside of the crown is always in contact with coolant.
- Piston is partially filled with coolant at slow running of the slow speed engine
- Cocktail Shaker (splash method) cooling effect
- Modern engine is bore cooling and equipped with jets for slow running

Capacity of Coolant Pump

- To maintain designed coolant flow rate
- Low flow rate will cause overheating of piston and consequences
- High flow rate will cause under cooling of piston and consequences i.e. poor combustion; cold corrosion and effect scavenge temperature

Stress on Piston

- Piston is subjected to compressive and tensile stresses caused by bending action due to gas pressure, inertia forces and thermal stresses.
- The top surface of the crown will be subjected to compressive loading & bottom surface to tensile loading in fluctuating nature.
- The thermal stress set up in a piston is caused by the difference in temperatures; this stress Is greatest where the difference in temperature of the material across any section is greatest.

- *When the crown of a piston is subjected to gas pressures the top surface of the piston is under compressive loading and the lower surface is under tensile loading.*
- *At the end of the stroke when retardation occurs, the inertia effect tends to cause the piston to how upwards so that the top surface of the piston, together with the sides, is under tensile loading and the lower surface of the crown is under compressive loading.*
- *When the piston is retarded on its approach downwards to BDC, the piston crown tends to how downwards, and its upper surface & the piston walls are in compression and the lower surface of the crown is then in tension.*

Diametrical Clearances of Piston

Piston diametrical clearance in liner is necessary to take up thermal expansion & distortions in admissible range. The body of the piston must be reasonably good fit in the cylinder in order that the piston rings have a minimum overhang.

- ⇨ In 2 stroke engine piston diametrical clearance is 0.2% of cylinder bore
- ⇨ In 4 stroke engine piston diametrical clearance is 0.1% of cylinder bore.

These figures may be increased when wear rings are fitted but excessive clearance between piston & liner can be extremely detrimental due to

- Defective piston ring action
- High lubricating oil consumption
- Blow past of gases (may lead to c/c explosion in trunk type engine & scavenge fire in cross head type engine)
- Scuffing and excessive wear of piston rings
- Seizure of piston in the liner in extreme cases.

Difference between Water Cooled and Oil Cooled Piston

Oil Cooled Piston	**Water Cooled Piston**
No risk of contamination	Chance of water contamination in oil
No extra pump or pipes required	Extra pump and pipes required
Costly, excess oil required	No cost of water
Low specific heat capacity (2)	High specific heat capacity (4)
Low temp difference with piston crown	High temperature gradient with crown
Carbon deposits at high temperature	No chance of deposit is if cooling water is treated
Oil oxidized at high temperature	Can operate at high temperature
No hardness scale formation	May form hardness scale

Inspection of Piston

- Piston crown
  - ⇨ Burning at top part and wear at side wall of crown & ring grooves
  - ⇨ Cracking at top (thermal & mechanical due to high temperature corrosion)
  - ⇨ Hot corrosion at top surface and acidic corrosion at lower part
- Piston ring & groove
  - ⇨ Free movement of piston rings
  - ⇨ Ring clearance / groove clearance
  - ⇨ Wear stepping and scuffing
- Piston skirt & side wall
  - ⇨ Any rubbing marks
  - ⇨ Wear down of wear ring
- Cooling passage
  - ⇨ Scaling due to poor water treatment
  - ⇨ Cocking due to high temperature
- Locking bolts & wires, studs and O' ring condition

Inspection & Maintenance

- Periodical inspection through scavenge ports
- Overhauling accordingly or as per PMS
- Conditions monitoring through process analysis

Gudgeon Pin Boss Failure

- Above boss circumferentially
- Longitudinally top of boss
- Lower ring groove closely above pinhole

Piston Repair

- Gauge piston crown and ascertain shape & wear down beyond recommended limit
- Examine for fractures or cracks, piston rings grooves & general condition
- The crown will be welded up with proper weld metal to correct shape & height above datum
- Piston rings to be welded up and examine after welding is completed
- If it is in order it will be heated up
- Piston crown & grooves to be machined

Piston Related Problems

Faults in Piston	**Cause of Piston Running Hot**
⇨ Cracking: Piston crown and upper piston wall mainly	⇨ Inadequate circulation of coolant
⇨ Burning : Piston crown top surface	⇨ Excessive deposits in cooling passage
⇨ Sealing : Piston cooling chamber and passage	⇨ Poor cylinder lubrication
⇨ Stepping: Edge of piston ring grooves	⇨ Faulty piston rings
⇨ Wear : Wear ring, piston skirt and side wall	⇨ Cylinder liner distortion
⇨ Corrosion: Hot corrosion on piston crown and acidic corrosion under crown	⇨ Piston misalignment
	⇨ Engine/Unit overloading
	⇨ Excessive water in fuel
	⇨ Insufficient combustion air
	⇨ Late fuel injection
Main Reasons:	⇨ Poor combustion
⇨ Sever thermal & mechanical stresses	
⇨ Fluctuating gas load	**Piston Crown Burning**
⇨ Excessive scaling	⇨ Poor combustion conditions
⇨ Cavitation erosion	⇨ Closely directed fuel sprays
⇨ High coolant temperature	⇨ Fuel valve characteristics
⇨ Local impingement from fuel	⇨ Alterations of air swirls – directing flame front
⇨ Poor atomization & high penetration fuel	⇨ Towards crown
⇨ High water content in fuel (slow down combustion)	⇨ Heavy local cocking on crowns

Actions in case of Piston Running Hot

In case a piston is running hot during operation, following immediate steps are essential:

- Inform bridge & reduce engine speed, Sudden stopped can result in seizure of piston
- Cut out fuel to the affected cylinder to prevent further addition of heat to the piston
- If possible, do not stop engine & allow piston to cool down before stopping
- In case the engine has to be stopped, turn engine by Turning Gear until piston cools down to normal.

Causes of piston seizer

1. Heat of combustion.
2. Heat of piston ring rubbing against liner.

These heat must be conducted away by piston cooling system, jacket cooling system and scavenge air system, and supply sufficient cylinder oil.

The piston would become so hot due to cooling not sufficient, excessive deposits in cooling spaces, insufficient lube oil, low temperature of cylinder cooling water, misalignment of piston rod, distorted liner, excessive slackness of crosshead guide or insufficient air from turbocharger.

Then the lubricating oil on the cylinder wall would be vaporized and the friction of the piston rings becomes so great that the metal would fuse and seizure occurs.

PISTON RINGS

FUNCTIONS

(01) To provide an efficient reciprocating gas seal with proper radial wall pressure (blow by control) without scuffing.

(02) To prevent excessive build up of pressure in the crankcase which will cause crankcase explosion in the case of dry sump engine.

(03) To act as a scraper and oil control avoiding excessive oil consumption which could result if lubricant is allowed to leak past into the combustion chamber.

(04) To conduct heat away from the piston into the liner wall.

Requirement of piston ring

1) Have spring action

2) Have low coefficient of linear expansion

3) Can resist high temperature & pressure

4) Good wear resistance

CAUSES OF PISTON RING FAILURE (Breakage)

1) Insufficient piston ring and groove clearance:(vertical clearance 0.4 mm for top ring 0.2 mm for lower rings)

2) Insufficient lubrication

3) Insufficient Ring gap (butt clearance 0.5 % of cylinder bore, for moderate rating and 1.0 % for higher rating. Over 500 mm bore)

4) Large amounts of wear in cylinder liners

5) Excessive wear on piston ring leading face in the piston ring groove

6) Excessive diametrical clearance between the piston and cylinder

7) Excessive relieving at ring edge (Oil wedge action cannot be attained)

8) Excessive lubrication (Excessive ring zone deposits and fouling of grooves and micro seizure may occur)

9) Ring sticking in ring grooves

10) Improper ring material

11) Improper fitting

12) Misalignment of piston

13) After burning

Causes of piston ring sticking

1) Continued overload running

2) Defective oil filtration

3) Excess sulphur & ash content in fuel

4) Faulty fuel combustion

5) High rate of cylinder lubrication

How will you check piston ring breakage?

1) By listening by stethoscope (running)

2) By taking compressing card
3) By checking its spring action form peed holes (during stopping engine)

Piston rings

Materials : Cast Iron Alloy /Ordinary Grey Cast Iron

Piston ring Material Properties

- High mechanical strength and good tension properties
- Elasticity and wear resistance with low friction
- Must be corrosion resistance and resistance against high temperature
- Self lubricating properties and compatible with cylinder material
- Compatible with piston for thermal expansion to maintain ring groove clearance

Piston Ring Design Factors

- Piston ring surface temperature, liner surface temperature and ring groove temperature
- Piston ring surface finish and cylinder liner surface finish
- Engine design feature to ensure adequate cooling

Optimum Sealing of Piston Rings

- Piston ring should be well lubricated and must work with minimum lubrication
- Piston ring should move freely in the groove
- Piston ring & groove and cylinder wall should be proper shape
- Must seal under condition of high temperature & pressure
- Must be extremely compatible with the bore / surface of the cylinder
- Must have sufficient strength to withstand high shock loads owing to firing impulse
- Must be of free shape to conform cylinder bore at operating temperature of minimal high pointing around its periphery.

Piston Ring Clearances

Butt / Gap clearance

- Butt clearance 0.4 ~ 0.5 % of cylinder bore and it is measured by placing ring squarely in ring gauge
- Should be as small as possible (as per maker's instruction) but should never close completely
- If the ring gap is inadequate the ring may break due to a restriction on its free expansion when coming up to working temperature. Whether a ring breaks or not, it may scuff the liner due to heavy wall pressures causing the oil film to break down or at least causing large increase in liner wear

Axial clearance

- It is essential for free movement during operation
- Insufficient vertical clearance will stick or break in the groove when they come up to working temperature
- To be kept minimum to avoid ring hammering / ring groove wear

Back clearance

- Must be as small as possible
- Large clearance is conducive to oil pumping

Ring Joint Ends may be:

- But (Vertical Cut) – Gives a robust joint for top rings
- Scarped (Diagonal / Angle Cut) – Better gas seal but less robust
- Lap / Bayonet Joint – Good gas seal, vulnerable to breakage & used in lower rings

Piston Rings Inspection

In good condition Running surfaces will be bright Move freely on grooves Not unduly worn, and it should be well oiled Edges will be sharp without burns **Micro-seizure / Scuff** Scuffed and hardened Good 'mirror surface' deteriorated Appearance of vertical strips / sharp burrs if extensive seizure occurs **Piston rings scratched** Due to hard abrasive particles or catalytic fins Enters cylinder via fuel Can have serious consequences **Lubrication condition**	**Sticking** Thick and hard deposits of carbon Cannot move freely in grooves Due to lack of sealing i.e. gas blow by **Breakage / collapse** Blackish appearance Lack of 'Elastic tension' **Piston ring blow-by** Black dry areas on rings Black dry zones on upper part of liner wall **Deposits on Piston** On the side of piston crown On the ring lands Lack of gas sealing is cause blow by

Reasons for Rings Replacement

- If piston rings wear rate is such that it will be unsafe up to the next maintenance schedule.
- If a piston rings is found stuck in the ring groove and if it wears more on one side than another.
- If the axial height of the rings is reduced so that a large clearance is found
- If performed piston rings having pressure variations around their circumference are fitted in any groove and micrometer measurements show variation in the radial thickness of the ring
- If the chrome layer on chromium plated piston ring is worn through or worn very thin.

Reasons for piston Rings failure

- Insufficient piston rings and grooves clearances, which cause the ring to jam in the groove at working.
- Insufficient cylinder lubrication.
- Large amount of wear in cylinder liner.
- Excessive diametrical clearance between the piston and cylinder liner
- Excessive wears on piston rings landing face in the piston ring groove
- Ring gap too small. This usually leads to ring breakage, but could ultimately lead to disastrous consequences.
- Incorrect preparation of ends of piston ring adjacent to gap.
- Radius at top and bottom of exhaust and scavenge ports in cylinder liner inadequate, the ring then receiving a shock when sliding past the port edges.
- Wear on the port bars relative to cylinder liner working surface is such that surface of the bar is below the surface of the liner.

Piston Ring Treatment

- **Chromium Plating**
  - On the running surfaces of compression rings and the sharp edges of scraper rings.
  - Used in 4 stroke engines but not used in chromium plated liner.
- **Plasma Coating:** Spraying method at Plasma State (4^{th} state of matter)
  - Gas mixture → N_2 & H_2 or Argon gas at temperature 10,000 – 15,000°C most materials & mixture melt
  - Molybdenum → High resistance against scuffing but poor heat resistance, Copper → Suitable for running in.
  - Compound of Cr, Ni, Mo & Cr Carbide → high resistance to corrosion, wear, abrasion and scuffing
- **Copper Plating**
- **Ferox Coating & Phosphating**

Wear Ring

- ⇨ Material ⇨ Bronze Alloy
- ⇨ Wear rings are fitted into circumferential –machined grooves
- ⇨ They are usually fitted in two pieces with good clearance at the butts to allow for thermal expansion.
- ⇨ They provide rubbing surface with low frictional characteristics and they prevent the hot upper side wall of the piston making contact with the working surface of the liner.
- ⇨ Working clearance is maintained by wear ring.
- ⇨ **In trunk piston engines** the use of wear rings allows the detrimental effects of trunk distortion, caused by the interference fit of gudgeon pins in the piston trunk. They are fitted above and below the gudgeon pin location.

Top Piston Ring Position and Working Condition

- ⇨ Piston rings give the best result when their working temperature is the lowest practicable.
- ⇨ So, it is necessary for the top piston ring, which has the severest duty to perform, should be well clear of the hottest part of the piston.
- ⇨ This is then imposes a limit to the minimum distance from the top of the piston to the upper most grooves.
- ⇨ The space formed between the side of the piston crown and the cylinder liner above the top piston rings is an area where carbon and ash from lubricating oil may encrust and build up
- ⇨ Working temperature should be as low as possible but too low temperature form carbon and ash deposits.
- ⇨ If carbon and ash flake away cause rapid abrasive wear on landing face of piston rings as well as liner.
- ⇨ Chromium plated piston rings is fitted only in the top piston ring groove.

Which material is harder between Piston ring and Liner ? Why ?

- ❁ Piston rings material are made harder than the material of cylinder liner in which they work
- ❁ This has the advantage of giving the piston ring a long working life by reducing the redial wear rate.

How can the life of a Piston ring and Cylinder liner be increased ?

Piston ring life can be increased with an increase in cylinder liner life, by fitting the top piston ring groove with chromium plated piston ring. This increases the hardness of the surface that makes contact with the working surface of the cylinder. Thus improve anti-friction conditions and consequently increasing piston ring and liner life.

Scuffing

Defined as a form of damage occurring between two sliding surfaces, when there is a breakdown of lubricating oil film separating the surfaces.

When scuffing occurs, the breakdown of lubrication in way of the high points or surface asperity is caused by very high-localized pressure on the high points. The heat generated by the friction between the high points on the cylinder liner and the piston rings causes the high points to weld together.

The movement of the piston and piston rings causes the weld to break away as soon as it is created and a roughened surface then results.

Indicating of Scuffing

Appearance of

- ❖ Slight roughening of the surfaces with light score marks
- ❖ Brownish to very dark brownish – Gray colour
- ❖ Increased hardness value of piston ring rubbing surface by hardness test

Factors Causing Scuffing

Scuffing may occur at any time, but it is more likely when cylinder liners, piston rings etc are new. Any factor, which cause or allows the lubricating oil film between the working surfaces to become disturbed, is likely a cause of scuffing. Some of the common factors are as follows:

- ⇗ Materials for liner & piston rings are not compatible.

- Surface finish of liner is too smooth, and thus has inadequate oil retention properties. [The surface of the liner must be smooth, but the honing marks at 45° to its axis should be deep enough to retain some lubricant and allows it to spread.]
- Unsuitable cylinder lubricant i.e. viscosity too high or too low. (Too high viscosity with too low cooling water temperature or too low viscosity with too high cooling water temperature)
- Defective cylinder lubricator or defective lub oil pipe to cylinder from lubricator
- Improper cylinder cooling water temperature
- Defective piston rings or high localized wall pressure on liner during running in period
- Improper scavenge air temperature or malfunction of scavenge air water separator
- Poor combustion or may be engine over loading.

Piston Rod Gland

Piston rod gland consists of

Upper gland group	**Lower gland group**
Scraper ring	Oil scraper ring
Seal ring	Scraper ring
Guide ring	Coiled garter spring
Coil garter spring	

- Upper section rings act as scavenge air sealing and scrape of dirty oil from piston rod on its downward stroke
- Lower section rings act as oil control rings and scrape of excess crankcase oil from piston rod during upper stroke.

CROSSHEAD

Function

- To minimize the force imposed upon the cylinder liner by the piston
- To provide long stroke of piston & get more engine output
- Causing the piston move centrally in liner

Crosshead problem

Load -High specific load & uneven load acting downward on lower bearing half.

L.O problems -

a). No chance for LO entering due to unidirectional load

b). Boundary lubrication due to oscillation movement (no relative movement)

Crosshead bearing is prone to failure, because of

1) High sudden load : Full effect of combustion, directly to the bearing

2) High bearing pressure : Bearing is placed high and the whole assembly reciprocates full length of stroke. So, limited bearing area results in high specific load

3) Distortion : Bending moment and deflection are maximum at centre, where pin is often bored to carry piston rod.

4) Poor lubrication : Due to following factures:

a). Slow oscillating movement where connecting rod swings through 25 ~ 30°, hence it is difficult to build up full fluid film

b). Reciprocating movement where oil supply is disturbed by vertical movement of pin and bearing.

5) Two stroke engine : **No load reversal**, which does not help the oil flow into the loaded part of the bearing.

Different approaches adopted to overcome crosshead bearing problems

1) ***Conjugate deflection :*** Bearing deflection follows that of crosshead pin. Natural deflections of pin and bearing remain inline, resulting in lower specific load
2) ***Crosshead mounted LO pump :*** Attached high-pressure pump, operated by connecting rod movement, press oil into bearing gap when bearing load is lowest
3) ***Large diameter stiff crosshead pin :*** Reduced Length / Diameter ratio, but pin deflection is minimum for uniform distribution of oil films over the whole bearing width
4) ***Continuous full length bearing face under pin :*** Low specific load on bearing. Load is transmitted directly downwards
5) ***Large diameter pin and smaller Connecting rod : Crank throw ratio:*** Obtained higher sliding velocity of the bearing, with better LO oil film, to carry high loads.
6) ***Hardened crosshead pin with high degree of surface finish :*** Surface finish is preferably better than 0.1 μm
7) ***Eccentric bored bearing :*** One of the finest designs for crosshead, which gives the same effect of load reversal (GMT engines)
8) ***Thin shell bearing :*** Bearing is renewable and pin is detachable. Produces high load carrying capacity, and better resistance against fatigue failure. Thin shall gives true circular shape, which improves lubrication characteristics.

Crosshead.

The crosshead bearing is a particularly highly stressed element and the lube oil film in it is extremely thin, because of oscillation motion only and because of no load reversal for the entry of the lube oil. These problems are solved by following methods

1) Pumps mounted on crosshead.
2) Increasing the lube oil pressure.
3) Use of conjugate bearing.
4) Use of large diameter stiff short pin.

STUFFING BOX

Function

To prevent the piston rod taking up oil from the crankcase and to counter act the leaking out of scavenge air.

Where fitted : At the bottom of the scavenge air boxes.

How to check it during engine running ?

- By watching the outlet from test cock on manoeuvring platform.
- Leakage of air indicates that sealing rings are defected
- Excessive oil outlet means that the scraper ring need overhaul

Check point when overhaul

- Check clearance of rings (vertical, gap)
- Check spiral spring tension
- All drain holes cleaned
- Check the fitting bolt. Renew locking washer, Renew 'O' ring.

THRUST BLOCK

Where

Between flywheel & engine end rest on tank top & is connected solidly with the engine bedplate.

Purpose

To prevent axial movement of the crankshaft which would result from the thrusting effort of the screw propeller.

It is designed that the total thrust is conveyed to the hull of the ship by the lower half casting.

What consist in ?

- ⇨ Thrust shaft
- ⇨ Collar
- ⇨ Bearing pad (forward & aft)
- ⇨ Pad carriers
- ⇨ Adjusting liner (or) distance piece

Why pivot line on pads provided ?

For to tilt & to form wedge shaped film between the faces of collar and the pad.

How will you check clearance ?

1) Remove top covered

2) Insert a feeler gauge between face of collar and the pad (both ahead & astern) take the reading

3) Force the shaft aft by means of a screw jack placed between casing and the back of the coupling until the collar is hard up on the pads.

4) Check position of the shaft is truly central in the journal bearings.

5) Test also that both liners are bearing equally on the casing.

6) Take a micrometer (a dial gauge) reading of the shaft position.

7) Repeat this operation, moving the shaft forward, and take a second micrometer reading.

8) The difference in the two readings is the total clearance. (about 1 mm being typical)

9) If clearance is excessive or less, it can be adjusted by subtracting or adding shims to the distance pieces on the back of the pad carriers.

- ✎ Feelers can be used as an alternative between thrust ring and casing. Use of feelers in the thrust pad/collar gap is likely to cause damage and may give a false reading.

- The radial clearance of the journal bearing can be measured by taking lead reading or roughly by means of a feeler gauge after removing oil seal on the end cover.

Axial clearance	=	1 to 2 mm
Radial clearance	=	0.5 to 0.8 mm for 440 mm diameter

Advantages of Tilting Pad Bearing

- Have ability to absorb, change in direction of load, more readily
- Have greater flexibility to absorb shaft deflection or misalignment
- Tilting of pads, allow oil to form wedge shaped film, between faces of collar and pads.
- Wedge shaped oil film prevents metallic friction and enables the thrust pads to carry loads.

Disadvantages

- Each pad in a set must be exactly the same thickness and even a ‘thou’ difference might result in a single pad carrying the entire load, thus increasing the risks of failure.

FUEL VALVE

FUNCTIONS

Fuel valve is one of the vital parts of the Diesel Engine due to their high precision in manufacturing and the intricate duties it has to perform, to atomiser, penetrate and distribute as swirling action achieved.

Atomisation

Atomisation is the splitting up of the fuel into very small droplets by the fuel injector, forcing fuel at high pressure through small atomiser holes.

The droplet size will depend upon the size of holes and the pressure difference between fuel pump discharge and that of the compressed air in the combustion chamber, and consequently the size of droplets may vary.

Atomised droplets have a high surface area to mass ratio, giving good heat transfer and causing efficient combustion with minimum of unburnt fuel.

Atomization – to ensure that each minute particle of fuel is surrounded by particle of oxygen with which it can combine.

Atomization. Is the break up of the fuel charge into very small particles it is injected into the cylinder.

Penetration refers to the distance that the fuel particles travel or penetrate into the combustion chamber.

Why fuel is required to atomise ?

- **?** To get complete (fully) combustion of charge fuel within a short time.
- **?** To ensure that each minute particle of fuel is surrounded by particle of oxygen

Excessive Atomisation

1) Smaller oil particles have insufficient KE, to go through combustion chamber
2) Dense compressed air has high resistance to the motion of oil particles
3) Smaller particles tend to cluster around injector tip, and oxygen-starved during combustion
4) Can cause after-burning

Insufficient Atomisation

1) Oil particles become larger and will have more KE and travel further into combustion chamber, and some may rest on cylinder liner and piston crown.
2) Carbon built-up around the top of cylinder and piston crown
3) Lower rate of combustion and after burning

Penetration

It refers to the distance the oil droplets travel into the combustion space before mixing with the air and igniting.

This will depend upon droplet size (atomisation), velocity leaving the injector and the conditions within the combustion chamber. It is desirable that fuel should penetrate into the whole of the combustion space for efficient space utilisation and good mixing, but droplets should not impinge on the internal surfaces before burning. The number of atomiser holes and their position will decide the spray pattern.

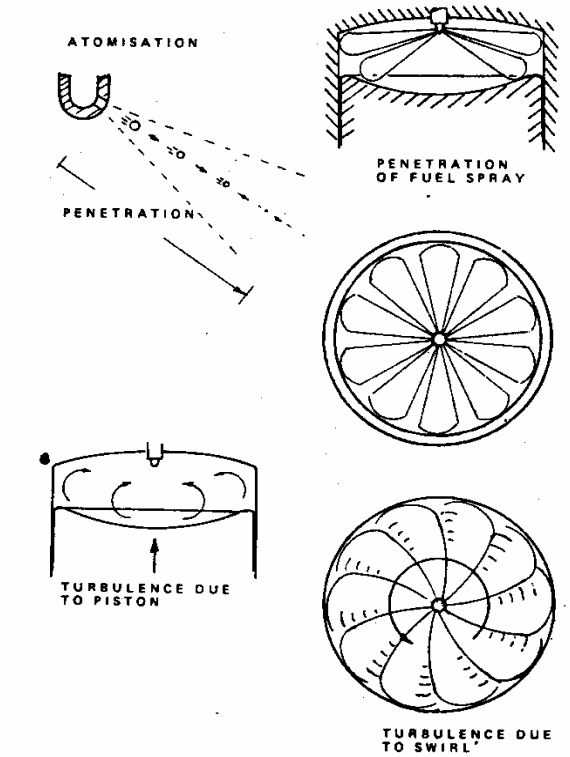
Low Penetration

1) Less intimate mixing of air and fuel particles in combustion chamber
2) Fuel cluster around injector tip causing after burning

High Penetration

1) Fuel particles travel further into the combustion chamber and some may rest on the cylinder liner and piston crown

2) Lower rate of combustion and after burning



Turbulence

It is the movement of compressed air and fuel within the combustion space before combustion occurs. This may have several causes. Swirl is imparted to the air during its entry at scavenge ports. It may be further agitated by the furl spray pattern and the shape and movement of the piston crown.

Turbulence will improve the mixing of fuel and air for effective and rapid combustion. It is particularly desirable for rapid combustion of heavy fuels in medium or higher speed engines.

Propose of cooling to nozzle tip

- To prevent carbon trumpet (or) formation & needle valve seizure
- To maintain the tip region temperature within acceptable limit
- To avoid the malfunction of operation mechanism

How to check the fuel valve is OK or Not ?

- Set pressure (on pressure gauge)
- Atomization (visual check & listening jarring noise)
- Spray pattern (by maker supply spray pattern plate, holes on it must not touch the oil or paper method @ right angle to valve)
- Dribble (sensing hand feel after correct pressure test)

Effect of trumpet formation ?

1) Interfere the spray pattern

2) Increase fuel consumption

3) Poor combustion resulting in black smoke
4) High exhaust temperature

Fuel valve overhaul ?

1) Test & check the old valve
2) Slacken the lock nut & adjusting screw to release spring pressure
3) Make upside down & remove retaining cap nut, take out nozzle & dowel pin fitting
4) Make upright, remove lock nut, adjusting screw, spring, spindle and spring retainer
5) Clean all parts with kerosene especially on nozzle holes check all parts thoroughly & renew if necessary

Check point:

- Nozzle hole diameter with pin gauge (Maker supply)
- Needle valve surface
- Valve lift
- Spindle for straightness
- Spring tension
- Lock nut & pressure adjusting screw wear & tear
- Body especially oil passage

6) Reassemble correct sequence and set the pressure on test pump and check the following
   a. Set pressure (some holding pressure)
   b. Atomisation
   c. Spray pattern
   d. Dribble

What point do you check when overhaul fuel valve ?

- Needle valve lift
- Seat clearance (tilted 30 ° from horizontal position needle must not fall down)
- Nozzle atomisation hole
- Spindle & spring
- Fuel line & Cooling Water line to be clear, dowel pin fitting)
- Contact surface of nozzle and body

Excessive needle valve lift

1) Spring failure
2) Impact damage between needle shoulder and thrust face & impact damage at the seat
3) Combustion gas may blow back into nozzle due to prolonging opening period

Too low/small needle valve lift

1) Restrict the flow
2) May overload the pump

Anti-dribbling arrangement

The angles of the needle valve and its seat are cut difference about 1 ° or 2 ° to achieve point contact thus preventing dribbling and sharp closing.

In other words, weeping and dribbling has been prevented by cutting the needle angle about 2 ° larger than the seat angle of about 60 °. This arrangement ensures sharp opening and closing of the fuel valve.

Worn nozzle hole

It is due to erosion of fuel oil which contains abrasive particles. That is due to insufficient filtration and purification or the fuel valve does not close snappily after injection.

It affects the spray pattern and atomization. It cause burning away of piston crown due to the fuel impingement and secondary burning and seriously effects engine performance.

How to decide nozzle is suitable for further used ?

- ⇨ By titling the nozzle body & needle valve assemble 30 ° from horizontal position.
- ⇨ If the needle valve falls from the nozzle body at only a slightly tilting angle the whole sprayer must be renewed.

Nozzle leakage

It is due to defective needle valve of partial opening of needle valve. It is due to defective delivery valve of fuel pump that causes dribbling of needle valve.

It may causes secondary burning, reduced combustion efficiency and high exhaust temperature. It may cause trumpet formation of carbon on the nozzle tip.

How to detect leaking fuel valve ?

- ⇨ Loss in power in affected cylinder (Power card)
- ⇨ Smoke at exhaust
- ⇨ Exhaust high temperature
- ⇨ There may be a knock or pressure wave in the injection system
- ⇨ Draw card show fluctuations of pressure during expansion process due to secondary burning of fuel leaking, higher expansion line.

Affect of leaking fuel valve

- ⇨ Increase fuel consumption
- ⇨ Engine over loading
- ⇨ Knocking
- ⇨ High exhaust temperature
- ⇨ Lifting of cylinder relief valve.

FULE VALVE TESTING

- To pressure-test a fuel valve:
- The valve is connected to a test pump with pressure gauge.
- The passages are primed by pumping oil freely and all air forced through the valve air vent when the spring tension is low.
- The correct lifting pressure is stated on the adjustment sheet for the engine.
- The adjusting screw for the spring is now set so that the spindle lifts at this pressure: the screw is then locked in position and the lift pressure rechecked. If everything is in order, the needle valve will open suddenly when the correct pressure is reached.

- Next, the nozzle is wiped thoroughly clean and pressure reapplied, this time to 10 kgf/cm2 below the injection working pressure. If the pressure remains steady for a few minutes, the valve is tight. A trace of oil at the nozzle holes is of no importance, as the valve will normally be worked-in completely after a few minutes of running. However, should the nozzle become wet or should drops appear, then replacement or regrinding of the valve is necessary.
- Condition of the spray holes can be checked by placing a piece of cardboard just below the Tip (not held by hand) and depressing the tester handle briskly once.
- The pattern (for a symmetrical nozzle) should be symmetrical.
- Observe whether the nozzle 'chatters' whilst the fuel is discharged.
- Injectors should be tested when removed, as a diagnostic check on their condition, and after recondition.

Opening pressures set too high can result in spring failure. If the opening pressure is adjusted low, combustion gas can blow back into the injector and build up lacquer and carbonaceous deposits.

Atomization test

Test handle is to be pushed hard two or three times.
To see fuel spray pattern is uniformly
Not dripping
Listing jarring noise.

~~Pressure drop test~~ (Set pressure test)

~~300 kg/cm^2 → 200 kg/cm^2 (30 to 90 sec)~~

Dribbling test

Maintain oil pressure of 10 kg/cm2 below opening pressure
Check nozzle tip

Spray pattern test

Original test bench has hole plate (same number with nozzle hole) when the spray can enter into the hole without touching the plate.
Paper method → fuel valve and paper right angle position.

Incorrect spring pressure setting

It is due to

1) Broken spring
2) Loose pressure adjusting nut and loose lock nut
3) Incorrect initial pressure setting
4) Sticking of spring
5) Worn out spring

It may cause

Early injection (low pressure setting)
Late injection (high pressure setting)

Early injection may causes knocking the engine unit. Shock heavy load on bearings.

Late injection may causes high exhaust temperature with reduced engine output and fouling of exhaust system.

How to know fuel valve spring is broken ?

- Over fuelling
- Engine knocking
- Black smoke from funnel
- Exhaust temperature high.

Chocked nozzle cooling space

It is due to insufficient pressure of cooling liquid (if in separate system). It is due to choked cooling line due to internal corrosion that is resulted from failure of anti-corrosive liquid to be added into cooling water system.

It may be due to incorrect alignment of nozzle holder and nozzle. The choked nozzle cooling carbonization of nozzle tips and clogging of nozzle holes.

* scale formation, sticking of nozzle needle*

EXHAUST VALVE

Function

It is used for expelling the burnt gases from the engine cylinder it seals gases on compression and combustion periods.

Why need to rotate the exhaust valve ?

- ⇨ To distribute evenly wear on valve & seat
- ⇨ To loosen the seat deposited
- ⇨ To extend the valve operation life
- ⇨ To reduce wear of valve seat

Why exhaust valve burn ?

1) Incorrect valve closing (or) incorrect tappet clearance
2) Insufficient cooling
3) Incorrect fuel valve spray angle
4) Overload running
5) Poor combustion
6) Vanadium attack due to use of bad fuel
7) Valve spindle not rotate
8) Unsuitable material

Cause of Exhaust valve burning

- ☞ Continuous overloading of engine or particular unit
- ☞ Poor combustion (or after burning) of fuel due to dirty fuel injectors, incorrect fuel injection pressure, incorrect fuel temperature , late fuel injection timing , air starvation, water or impurities in fuel.
- ☞ Valve not closing properly due to incorrect tappet clearance or starvation of closing air.
- ☞ Insufficient cooling water supply may cause the valve to overheat
- ☞ Hot corrosion due to bad quality fuel, which contains high vanadium, sodium etc.
- ☞ Unsuitable material used.

Indication of Exhaust leaking

- ☞ Indicates high exhaust temperature in that unit
- ☞ Indicates low compression pressure and low peak pressure in the indicator diagram
- ☞ Low compression pressure and low peak pressure can be a cause of shortage of air supply, but in that case scavenge air or supercharging air pressure will increase abnormally.

Indication of exhaust valve leaking ?

SYMPTOMS

- High exhaust temperature
- Noise
- Smoky operation
- Low Pmax
- Low Pcomp
- Abnormal light spring diagram showing pressure dropping down

CAUSES

- Cylinder power in excess of design rating
- Poor combustion of fuel (after burning)
- Valve not closing properly due to incorrect tappet clearance

- Insufficient cooling
- Incorrect hardening down of exhaust valve on cylinder head leading to valve seat distortion
- Incorrect valve seat material

RESULTS

- Disturbance to Voyage
- Burning of exhaust valve and seat by high velocity hot gas
- Surging of turbocharger
- Fouling of exhaust system
- Uptake fire

PREVENTION

- Avoid excessive power and combustion efficiency
- Regular and proper Overhaul
- Regular check of Tappet clearance
- Proper hard facing material for valve and valve seat so as to avoid hot corrosion leading to leaking exhaust valve
- Proper Bore cooling arrangement
- Proper Valve rotation during service
- Correct valve and seat angle
- Proper Design (Inner contact or any late coming practice)

Excessive tappet: Late open, close early

Cause ▸ Noise; reduce maximum lift of the valve, damage from impact on working surface

Insufficient tappet: open early, close lately

Cause ▸ Increase maximum lift prevent valve closing completely, hot gases to blow pass valve faces & burn the valve

Purpose of tappet

- To allow for thermal expansion of valve spindle
- To ensure that positive closing of the valve.

Why two spring fitted ?

- To prevent falling exhaust valve if one spring damage
- To prevent bouncing effect when it close

To long the exhaust valve life

- Rotator or vane fitted
- Sufficient cooling provided
- Satellite coating at valve seat

EXHAUST VALVE KNOCKING (For two stroke)

Exhaust valve knocking is caused by insufficient cushioning in the hydraulic system. This is due to three different reasons. Basically,

01. Deficiencies in the oil supply
02. Errors in the air spring
03. Excessive leak in the high pressure oil system

01. **Deficiencies in the oil supply** can, for instance, be:

1a). Air in the oil (foaming), most possibly caused by air being drawn-in at the pump via suction side

1b). Too low supply pressure

1c). Too high oil temperature, giving low viscosity

02. <u>Errors in the air spring system</u> can be:

2a) Incorrect supply air pressure (too high)

2b) Defective safety drain valve

Supply air pressure	Safety Valve opening pressure
5.5 bar	17.5 bar
7.0 bar	21.0 bar

03. <u>Excessive abnormal leakage in the high-pressure oil system</u> can, for instance, be:

3a) A maladjusted or defective throttle screw
3b) The oil cylinder piston rings, on either cams or exhaust valve sides
3c) The oil cylinder safety valve, on the cam side
3d) The punctured or leaked non-return valve
3e) High-pressure pipe joints
3f) The venting valve at the top of the exhaust valve

Exhaust Valve

Exhaust Valve Material

- Valve seat ⇨ satellite material
- Valve Lid ⇨ Nitride/Nimonic
- Valve Spindle ⇨ Nimonic material
- Valve Cage ⇨ Pearlitic cast iron
- Valve guide ⇨ Pearlitic cast iron
- Valve Bush ⇨ Bronze

Material Properties

- High tensile strength & creep resistance properties
- Resistance at high temperature properties
- Resistance to high temperature corrosion.

Exhaust Valve Improved Design

- Bore cooling for efficient cooling system (as low as 327 °C at full load)
- Valve rotational mechanism
- Heat and corrosion resistant material used
- Hydraulic push rod with controlled valve landing speed
- Air spring (or increase number of spring with improved material) to reduce valve bouncing
- Guide bush is sealed by pressurized air
- For less obstruction of gases, use valve seat angle 30 ° instead of 45 °.

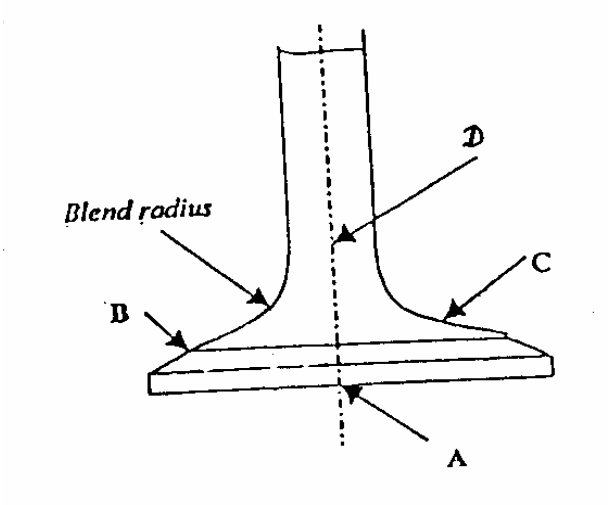
Exhaust valve Stress

- Thermal stress 3 times greater than mechanical stress
- Thermal stress in radial direction greater than axial direction
- Largest mechanical stress at the flame face centre (A)
- Highest thermal hoop stress (B)
- Largest mechanical stress in the radial direction along the blend radius circumferentially (C)
- Maximum combined stress at the valve neck points. (C& D)

Stress Failure

- Circumferential and radial cracks around head radius
- Breaking at the neck
- Radial crack at the seat
- Dishing in the head

- Crack at the flame face



Exhaust Valve Problem

- Burning due to high temperature : Use bore cooling
  : Use valve rotational mechanism
  : Use Nimonic material
- Seat trumping and wear
- Valve bouncing : Use air spring &hydraulic actuator
  : Or increase number of spring with improved material
- Hot corrosion and erosion at the valve seat & its underside
- Possibility of scaling due to poor water treatment
- Thermal stress due to heating and cooling
- Cracks at the seat and centre of the flame face
- Braking at the valve neck

Cause of high exhaust gas temperature read at engine operational faults

Explain exhaust valve burning process.

A small leakage results in local overheating of the leakage area, which builds up relatively slowly. The increased temperature, combined with the flow through the leakage, gives a higher corrosion/ erosion rate, gradually expanding the leakage and starting the *vicious circle*[1] that the valve spindle being sometimes burned beyond repair.

When engine is smoking, detect one unit fault or all units ?

Particular unit smoke may be detected by shutting fuel off from each cylinder by open each unit indicator cock and allow to blow on *wet rag* a deposit will show, it cause to smoke. (smoking unit or all unit fault)

What point to be check when engine is smoking ?

Check → Fuel pump
→ Charge air temperature and pressure (check by light spring)
→ T/C suction air filter
→ Fuel Valve
→ Draw card to be taken

[1] A situation in which one problem cause another problem which then makes the first problem worse.

How to do rotocap overhaul of cages exhaust valve ?

01) Take out rotocap from valve spindle after removing cotters.
02) Remove circlips of rotocap
03) Remove spring cover, Belleville washer (spring plate) springs and balls
04) Clean all parts in diesel oil
05) Check Belleville washer and balls for no wear
06) Check springs tension
07) Place balls and spring into the rotocap body, by means of fitting direction mark
08) Then place Belleville washer and spring cover
09) Then fit circlips, check rotate or not
10) Fit the rotocap to valve spindle with cotters.

FOUNDATION CHOCK

Function.

1) Any variation in the surface of the tank top does not cause misalignment.
2) Individual adjustment of chocks can be carried out.
3) Any distortion can be corrected.
4) End chocks absorbs collision loads. In case of integral thrust block, it absorbs propeller thrust and propeller excited vibration.
5) Side chocks absorb side loads due to components of unbalanced reciprocating forces. It helps holding down bolts to resist the lateral forces when the vessel is rolling.

Materials

Metal chocks Cast iron
Steel
Epoxy Resin chocks.

Purpose

01) To avoid misalignment on tank top surface
02) To carry out adjustments on individual chock
03) To correct any distortion
04) To absorb collision load by end chocks
05) To absorb side load, due to unbalanced reciprocating forces, by side chocks

Advantages Of Chockfast System [Eposy Chock]

01) Reliable and permanent alignment without machining foundation, bedplates or chocks.
02) Provides uniform precise mounting for superior retention of critical alignment.
03) Resists degradation by fuels, lubricants, eliminates corrosion in chock area.
04) Non-fretting condition permanently.
05) Reduces noise levels, maintaining alignment and hold down bolt tension.
06) The modulus of resin helps to maintain crankshaft deflection and machinery alignment during hull distortion.
07) Can be used on all sizes and types of engines
08) Installation time is measured in hours, not in days
09) Withstands the temperature up to 80°C
10) Gives chock thickness of up to 40 mm.

How to check Foundation Chock ?

1. Check according to running hour
2. Regular retightening done or not
3. Check for crack, fretting, piece or rust, scale etc
4. Check for slackness by hammer testing.

Fitting of chocks.
Record crank shaft deflection.

For metal chocks.
Machined slightly over size and then hand filed and scraped to fit. Surface contact 70%.
Record crank shaft deflection.

For Epoxy Resin chocks.
Cleaned surfaces.
Apply thin film of zinc to machine base and foundation for corrosion resistant.
Prepare dam in chock area. Greased up holding down bolts, inserted and hand torqued prior to pouring.
Chocking area is maintained at not less than 16°C by hot air blowers.
Resin is mixed and poured into position. Care that heating does not cause local hot spot.
When chock fast hardens, bring chock and adjacent plate to 16(C or higher for 48 hours. Ensure chocks are below 38(C before tightening bolts.

Bed plates

Forces
1. Forces of gas pressure in the cylinder.
2. Inertia forces of the moving parts.
3. Side thrust from guide faces.
4. Weight of all engine parts located above bed plate.
5. Torque reaction from propeller.
6. Hull deflection.
7. Vibration forces due to torque fluctuations, shock load.
8. Thermal stresses.
9. Forces due to ship movement in heavy sea.

Material
1. Prefabricated steel.
2. Cast iron.
3. Hybrid arrangement of cast steel and prefabricated steel. (Fabricated mild steel for longitudinal girders and cast steel for transverse girders.)

Machined surfaces
1. Top of frame attachment.
2. Side for side chocks and entablature cover plates.
3. End for thrust block housing, turning gear and end chocks.
4. Bottom for chocks, tie bolts, oil sump pan.

Faults in bed plate.
1. Crack.
2. Oil leaks.
3. Loose chocks.

4. Loose frames.

Cracks usually occurs at following spaces.
1. Fabricated transverse girders often show cracks in welds around the bearing pockets.
2. At the junction welds between fabricated cross girder and side girders.
3. Radially tie bolt and frame bolt holes.
4. Around lightening holes.
5. At the base of main bearing keeps.

Cause of bed plate failure.
1. Excessive vibration.
2. Slack tie bolts.
3. Overloading because of excessive bearing wear.
4. Poor welding.
5. Not properly stress relieved.
6. Stress risers on welds.

Repairs
Mild steel and cast steel - Crack should be chipped out and welded. Care not to distort the part. Use ductile electrodes which give deposit close to base metal.
Cast iron - Small crack - Arrested by drilling.
Serious crack - Metal locked.

Function

Cylinder heads form the top part of the combustion space. The primary function of the cylinder cover is to close the end of the cylinder and to seal the gases involving extreme pressures and temperatures. The cover is exposed to high mechanical and thermal stresses.

Material **:** Pearlitic or Nodular Graphite Cast Iron / Cast Iron

Properties
- Must be of sufficient strength to withstand the gas load at maximum pressure
- Resist bending and be symmetrical in shape
- Have a rate of thermal expansion compatible with adjacent parts and transfer heat readily.

Design Feature
- The cylinder head /cover forms the top part of the combustion space
- The head is of intricate design
- The cover lands on the top of the cylinder liner flange and is secured to the cylinder block by a number of cover studs and nuts. These are tightened hydraulically to maintain a gas tight seal under fluctuating pressure and temperature conditions.
- The cover must also locate and support all the valves required to operate the engine together with their securing.
- Large two stroke engine covers are machined from solid steel forging drilled to give bore cooling.
- They are circulated with fresh water from the jacket cooling system which maintains moderate temperatures and allows intensive cooling of exhaust valve seating while making separated fuel valve cooling unnecessary.
- Four stroke engine covers are usually formed from a casting, which may be of pearlitic or nodular graphite cast iron, or in some cases cast iron.

What DEFECT on cylinder cover ? Preblem

Burning: ⚓ due to flame impingement.

Cracking: ⚓ hairline crack between fuel valve and exhaust valve apertures. They are cause by over heating and casting strain.

Distortion: ⚓ Due to improper uneven tightening down of holding down studs, overheating, unrelieved casting strain the cylinder head can be distorted.

Corrosion and deposit: ⚓ cooling water is not suitably treated or maintained. (excessive scaling)

Check point when overhaul

1) Taken to make a thorough examination to the underside of the cylinder head. (Crack, burning)
2) Check Cooling space of fouling due to corrosion, scaling and sludges and cleaned inside
3) Check gasket landing surface
4) Check cooling water 'O' ring & replace
5) Check abnormal distortion
6) Defects must be searched thoroughly by using Dye penetrant and hydraulic test about 7 bar.
7) All the pockets and apertures must be cleaned and properly ground in.

How to maintain cylinder head ?

- 🛠 Evenly tighten down cylinder head bolts
- 🛠 Make regular cooling water treatment
- 🛠 Check & Clean cooling passage @ every overhaul
- 🛠 All the parts have to be thoroughly cleaned until exposure of bare metal.
- 🛠 Coolant treatment must be regularly carried out as per regular and accurate test.

Hot corrosion

- Vanadium Penta-oxide (V_2O_5) melting point 690°C and is a corrosive liquid
- Complex of Sodium (Na), & Vanadium (V) salts melting point 550°C and is a corrosive liquid
- At high temperature slug deposits on the valve seat, neck, casing and on cylinder head
- When temperature reaches at this melting point, slug melts and creates hole at this place.
- This type of burning of exhaust valve and cylinder head is called hot corrosion.

CYLINDER RELIEF VALVE

Function

To protect the cylinder against excessive pressure. The blow-off pressure should be adjusted 20 to 30% above the normal working load.

Causes of Relief valve Opening while Starting

1) Manoeuvring handle being moved too far causing fuel injection excessive.
2) Incorrect fuels pump timing causing over-fuelling.

3) Incorrect adjustment of fuel valve opening pressure (low).
4) Incorrect governor setting causing over-fuelling.
5) Fuel oils remain on top of the piston owing to:
A. Improper priming operation
B. Fuel valve renewal period
C. Fuel oil injected in previous fail-start operation still remaining on piston top.

Causes of lifting in service

- **?** Incorrect fuel pump timing,
- **?** Air start valve stuck open or wrongly timed.
- **?** Incorrect camshaft timing, chain breakage or Governor Fault especially in heavy seas.

Action if relief valve leaking

- ⓘ Inform bridge & reduced engine speed
- ⓘ Cut out fuel to concerned cylinder
- ⓘ Rotate the spindle on its seat until leakage stops

If it remained out of action

- ⓘ The engine stopped at 1st movement opportunity for replacing it with spare valve.

Why immediate action need ? ****

If leakage occur

- Hot & abrasive gases come out, the valve & seat may be burnt
- Minor leak may proceed to major leak and fire risk may occur

Why M/E cylinder relief valve are sometimes explored during the period of maneuvering.
Accumulated fuel oil due to
1. Incomplete combustion. (Remaining fuel in combustion chamber.)
2. Fuel valve dribbling.
3. Incorrect timing of fuel pump.

Remaining fuel combustion ~ excess pressure than normal.
Blow off pressure should be adjusted 20% to 30% above the normal working pressure.

CRANKSHAFTS

Function

- ⇨ Device for converting the reciprocating motion of the piston, driven by expansion of the gases, to rotating motion.
- ⇨ Power produced by the engine is taken off the crankshaft by a transmission.

Types of crankshaft

(01) Solid Forged **(02)** Fully Built **(03)** Semi Built **(04)** Welded

(01) Solid Forged The whole crankshaft is forged from a single piece steel billet.

Properties ⇨ More resistance to fatigue failure due to continuous grain flow

⇨ Cannot repair in section
⇨ Cost expensive
⇨ Used in small high speed engine

(02) Fully Built ⇩ All components of the crankshaft (pin, webs and journal) are made separately and then assembled into a complete crankshaft by means of shrink fit.

Properties
⇨ Easy to manufacture
⇨ Can be repaired in section
⇨ Used for large marine engine

(03) Semi Built ⇩ Crank throws and journals are made separately and then assembled into a complete crankshaft by means of shin fit only at the journal.

Properties
⇨ Lighter than fully built, so web size become less
⇨ Can be repaired in section
⇨ Continuous grain flow between pin & webs (popular design)
⇨ Used slow speed engine

(04) Welded ⇩ A number of parts (A crankpin and two webs, with a half length of journal on each web) are forged or cast separately and then welded together to form a complete shaft.

Properties
⇨ Easy to manufacture
⇨ Can be repair in section
⇨ Has resistant to fatigue failure

Why welded on Mid of journal ?
There is a low load area on mid of journal, where it is welded.

In large marine engine which type is used and why ?
Usually Semi-built is used because
ⓘ Only on shrink-fit between web and journal [less chance of slippage]
ⓘ Can get grain flow in way of web and pin
ⓘ Webs are smaller [no shrink-fit]
ⓘ Can be repaired section by section when damage occurred

Why crankshaft deflection taken (or) purpose ?
? To detect the axis of crankshaft journal deviate from the theoretical shaft axis
? Interpretation of crankshaft deflection gives an indicate of high or low bearing

WHEN TO TAKE CRANKSHAFT DEFLECTION ?
(01) At initial installation and after 1000 R / H
(02) At subsequent annual intervals if normal (6000-8000hrs)
(03) At foundation chock repair or renewal
(04) At the time of major structure has been disturbed, such as:
a. Propeller bending or impounding with something
b. Ship grounding

c. Docking (before and after)
d. After fire breakout

(05) At the time of main bearing overhaul or renewal or removal for survey.
(06) Damage on bearing bracket, holding down bolt, chock

CAUSES OF MISALIGNMENT

(01) Main bearing damaged
(02) Main bearing pocket cracked
(03) Wear of main bearing lower shell
(04) Wear and ovality of main journal pin
(05) Bedplate deformed – transverse girder damaged
(06) Slack or broken tie bolts
(07) Foundation chocks _ broken, cracked, or fretted
(08) Foundation bolts loose or fracture
(09) Defective propeller shaft bearing
(10) Weakening of structure due to corrosion
(11) Distortion of supporting ship's structure
(12) Lifting of flywheel side
(13) Hull deformation due to:
a. Excessive bending moment caused by carried cargo.
b. Grounding, and
c. Fire

RESULTS OF MISALIGNMENT

(01) Bending of crankshaft
(02) Fatigue failure owing to cyclic stresses
(03) Undue Vibrations within the engine
(04) Damage to main bearings

How to know the amount ?

⇨ Difference between the values at TDC and BDC indicates the amount of crankshaft deflection, during one revolution
⇨ Interpretation of crankshaft deflections gives and indication of high and low bearings

What will happen if a bearing is high or low ?

⇨ When a bearing between two cranks is *higher* than those on either side of it, both sets of crank webs will tends to *open out*, when the cranks are on BDC, and *close in* when on TDC.
⇨ Vice versa, if there is a low bearing between two cranks

Requirements when taking crankshaft deflection

? Hull deflection not excessive
? Bed plate not distorted or bearing pockets not worn

What will you do/record before taking crankshaft deflection ?

(01) Ship's draught and trim must be checked and recorded
(02) Engine room and engine temperature (must be taken in warn condition.)
(03) The ship must always be afloat
(04) Ensure that at all main journal pins are true without excess ovality.
(05) Ensure that the main journal pins are resting on the lower halves of main bearings. The bottom clearance must be almost zero.
(06) Ensure that foundation chock and bedplate alignment is true.
(07) Ensure that all foundation bolts are not loosening and the engine is firmly bolted down.

(08) Ensure that flywheel and end coupling arrangement is true.
(09) Loading condition
(10) Sea water temperature

Crankshaft Alignment Method

- **Bridge Gauge** →This method is satisfactory if
  - Hull deflection is not excessive
  - Bedplate is not distorted
  - Bearing housing is not excessively worn
- **Measurement of Main bearing bottom shell**
- Crankshaft Deflection → Combination of

Bridge Gauge & Deflection reading is satisfactory.

Where to put dial gauge, if no punch mark ?

Fitted between adjacent webs (at a point in line with the outside of the journal furthest from the crank pin) opposite the crank pin at the half diameter from the shaft centre

How to take crankshaft deflection ?

- Stop L.O pump, open crankcase doors both side, clean the oil @ entrance & on the webs
- Check dial gauge error &response
- Place the gauge at the punch mark on the webs
- Turned engine toward BDC with dial gauge close to connecting rod and set dial gauge zero reading with slight pretension
- Turn crankshaft ahead by turning gear, read & record values on dial gauge at both horizontal crankpin positions and at TDC.
- Turn crankshaft until clock gauge is close to the connecting rod on the other side. Record value at this position.
- Similarly other unit's reading taken and recorded, for the unit near flywheel before taking reading a little reverse turn must be made.
- All reading are tabulated & calculate for BDC reading
- The difference between values at BDC & TDC indicates the amount of crankshaft deflection during one revolution
- Interpretation of crankshaft gives an indication of high and low bearing

Crankshaft inspection procedure

1) Stop L.O pump, open crankcase door both side, engine turning gear
2) To check appearance of all parts inside the crankcase
3) To check bearing axial play & wipe out
4) To check bolt tightness
5) Make chain inspection
6) To check loosening attachment
7) To check locking arrangement
To check L.O system by running L.O pump
8) To check metal chip in crankcase & on the perforated sheet
9) To check crankcase relief valve (flame trap, spring) After inspection, check thoroughly any instrument & rags left in crankcase, closed the doors.

STERN TUBE

Water Lubricated Type

This design is now superseded by oil lubricated type

01) SW is used for cooling and lubricating this bearing. Open aft end allows SW to flow in with supplementary SW connection, piped into stern tube from ship's main.

02) A soft packing gland fitted at forward end and slight leakage is allowed to ensure cooling of packing

03) Tail shaft is protected by corrosion resistance bronze liner, shrunk or pressed on tail shaft, extending from propeller hub to forward of forward gland seal (continuous or single piece)

04) Liner may be continuous or in two pieces

05) Liner thickness, dictated by Classification rules, is 23 mm for 500 mm shaft

Advantages

1) Very hard and wear resistant

2) Natural lubrication assisted by SW

3) Low swelling due to SW absorption

4) Predictable wear rate allows scheduling of docking in advance

5) No sophisticated ford/aft seal required

Disadvantages

1) Higher wear rate due to large clearance and sue of SW as lubricant

2) Less load carrying capacity due to staved surface

3) Shaft needs extra liner for SW corrosion protection

4) Fatigue crack generating form corrosion pits could be the outcome, as galvanic action between shaft and sleeve (liner) is possible

5) More shaft movement and vibration due to larger clearance

6) Packing grips at forward end wears out liner unevenly

7) Oil is better vibration damper than water

8) Abrasives enter the bearing

Normal clearance : 0.003 to 0.004 of shaft diameter

Maximum clearance : Varies between 6 -10 mm.

Checking clearance (or) Wear Measurement is by inserting small wooden wedge or feeler gauge, between the *shaft liner and lignum vitae*, once the *rope guard* has been removed when ship is in dry dock

Wear rate

⇨ Cargo ship with engine amidships = 0.5 mm to 4 mm / year

⇨ Tanker or ship with engine aft = 1 mm to 13 mm / year

⇨ Lignum vitae size : typical length 9" x 2" width x ¾" thick

⇨ Clearance at which re-wooding required varies between 6 -10 mm.

Survey interval of tail end shaft

⇨ Single liner tail shaft to be exposed for examination every 3 years

⇨ Double liner tail shaft to be exposed for examination every 2 years

Oil Lubricated Type

1) Two bushes of white metal lined, grey or nodular cast iron are pressed into stern tube.
2) Mechanical seals are provided at both ends and stern tube space is filled with oil
3) Oil pressure is maintained slightly above seawater pressure by means of static header tank, keeping the static head pressure, 0.30 bar higher than seawater pressure

Advantages

- Less wear is experienced
- Very less power loss at bearing
- Less heat is generated
- Hydrodynamic lubrication can be established
- No bronze liner required in way of bearing
- No abrasives enter the bearing
- Oil is superior lubricant and good vibration damper
- Low clearance reduces shaft movement and vibration

Disadvantages

- White metal debris may choke and restrict oil supply, speeding up failure
- Contaminated oil supply, causes abrasive wear
- Prolonged low sped operation may allow only boundary lubrication
- Poor bonding of white metal to bush may exist
- Bearing metal failure due to fatigue
- Lack of oil supply, due to low level in header tank, obstructed flow, damaged pipe work.

Continuous length of bearing metal = 1.5 to 2.0 x shaft diameter, for aft end bearing
= 0.6 to 1.25 x shaft diameter, for forward bearing

Thickness of bearing bush : Varies according to Classification Society : 3.8 mm thickness for 300 mm diameter shaft and 7.4 mm thickness for 900 mm shaft.

Oil clearance : Depends upon Class and LR recommends 0.0015 – 0.002 of shaft diameter
Maximum clearance : 2 times original clearance

Stern Bearing Wear Measurement

01) Measurement at every dry dock and always should be measured at the same radial position with usually 4 reading taken at 90 ° intervals
02) '0' marks are stamped on the periphery of aft chrome steel liner flange. (Ideally chisel or similar marks should be left on the propeller boss. Alternatively the readings can coincide with the propeller blades.)
03) Measurement is taken at plugged oiling hole (top Check Plug) and drain hole (bottom Check Plug) of aft seal intermediate ring, through the seal housing. (To give max. accuracy it is recommended that readings be taken at top and bottom if possible, so that any eccentricity of the shaft is taken into account)
04) Mating marks are curved at top and bottom Check Plugs
05) In measuring, bring the '0' mark on chrome steel liner to fixed position at all times
06) Screws down the wear down depth gauge into the hole tightly and align the mating mark and '0'mark

07) Measurement is recorded in record sheet

Survey interval of tail end shaft : Special Survey at 4 years interval

Another Answer

1) *Use Poker Gauge or Wear down Gauge or Vernier Calliper*
2) *Remove rope guard*
3) *Take out Check plug and Drain plug*
4) *Turn the tail shaft until coincide the '0' marking on tail shaft (periphery of aft chrome steel liner flange) and stern tube [Sometimes measurement had been taken when No. 1 Unit was at TDC, and important thing is that it should b eat same radial position as last docking]*
5) *Measure at top hole and drain plug (bottom) through 180° at same redial position as previous docking.*
6) *Compare with previous readings.*

3 Types of sealing arrangement

01) Simple stuffing box
02) Lip seal type
03) Radial face seals

Lip seal type

01) Aft seal consist of three portions, 3 pieces of sealing rings, a metal housing holding the rings inside, and a liner which rotates along with propeller shaft
02) Lip type seals of 'viton' or 'nitrile' rubber seal rings, supported by garter springs and bear on stainless steel or bronze liner, which rotates along with propeller shaft
03) Typical aft seal uses 3 pieces of seal rings, outboard ring keep out dirt and SW, inner ring to retain bearing LO, while central ring provides oil space
04) Check plugs are fitted on top and bottom of aft seal intermediate ring, to check wear down of stern tube.
05) Forward seal consists of four portions, 2 pieces of rubber sealing rings, a metal housing holding the rings inside, and a liner which rotates along with propeller shaft, and a clamp ring holding the liner.
06) Sealing rings can withstand both tearing and maximum oil temperature of 110 °C

Prevention of oil leakage outboard in port

- Shut down stern tube LO system
- Close header tank valve
- SW pressure become greater than head pressure
- SW comes into the system

Notice : ***Prior to staring ME***

- Open stern tube LO system drain valve
- Drain out any water present
- Fill the stern tube space with oil completely

Minimising the amount of leakage at sea

Rate of leakage depends upon

- ⇨ Relative pressure head between header tank oil level and SW level above aft oil seal
- ⇨ Effective area of leakage
- ⇨ Viscosity of oil

Procedure to minimise leakage

1) Tip the vessel to allowable trim
2) Use more viscous oil
3) Place a temporary header tank of about 200 litre drum with flexible hose, at lower head. Position the drum in such a vertical height, that only a slight head pressure is exerted
4) Use lower header tank if provided

Stern tube oil : Oil is a compound type with sp. Gr. 0.95 and viscosity 300 RW No. 1 at 60 °C

Safety devices

⇨ Temperature sensor and pressure gauges are usually fitted
⇨ Oil pressure fluctuation with respect to ship draught, means leaking of oil seal

How to check Stern tube wear down ? (Lignum Vitae)

1) Measurement can be taken by Wedge Gauge or Feeler
2) If Wedge Gauge is used, the side of the Wedge contacting the bearing is chalked and inserted into the clearance space between top of the screw shaft and bearing
3) Gauge is pressed move and withdrawn
4) Clearance Is measured on the Wedge at the point where the chalk marking is scrapped of by bearing

For Oil Lubrication Bearing

1) 2 mm clearance
2) When the ship is on Dry Dock, release system oil and remove plug on the end of the stern tube, and insert Poker gauge to measure the distance from the datum to the top the shaft.
3) The difference between new reading and original measurement is bearing wear down value

All types of Stern Bearing

1) Fit a Dial Gauge on the Rope Guard or Stern tube Nut so that the Gauge spindle is vertical and touching the Propeller Boss
2) A hydraulic jack is placed on the Stern Frame Skeg at same point over a Keel Block so that the Skeg is supported
3) A wood shoe is placed between the jack and the Propeller boss
4) The jack is then used to lift the Propeller until the screw Shaft contact the upper parts of its Stern Bearing
5) The lift recorded in Dial Gauge gives the bearing clearance

Skeg : An arm extending to the rear of the Keel to support Ruder and protect Propeller.

Tail end shaft taper : ¾" to 1" per foot length

Stern tube bearing length

Aft bearing	4D	Forward Bearing 1 – 2D	(Water-cooled)
Aft bearing	1.5 – 3D	Forward 0.6 – 1.25D	(Oil cooled)

How will you check Stern tube Sealing in Dry dock ?

LO header tank is topped-up and checked for leakage for 24 hours

What action to be taken when SW leaks into stern tube oil system ?

Higher up the Stern tube oil tank level to counteract SW force

Stern tube Leakage Test

1) Oil to be used must not attack sealing Rings. Generally oil sued for main propulsion unit is SAE 30.

2) Fill up stern tube header tank & record the level

3) Remove screw plug. Oil pressure must amount to only 0.2 -.0.3 Kg/cm^2 more than SW pressure

4) Preheated to 60 – 70 °C when viscose oil is used or low temperature prevails

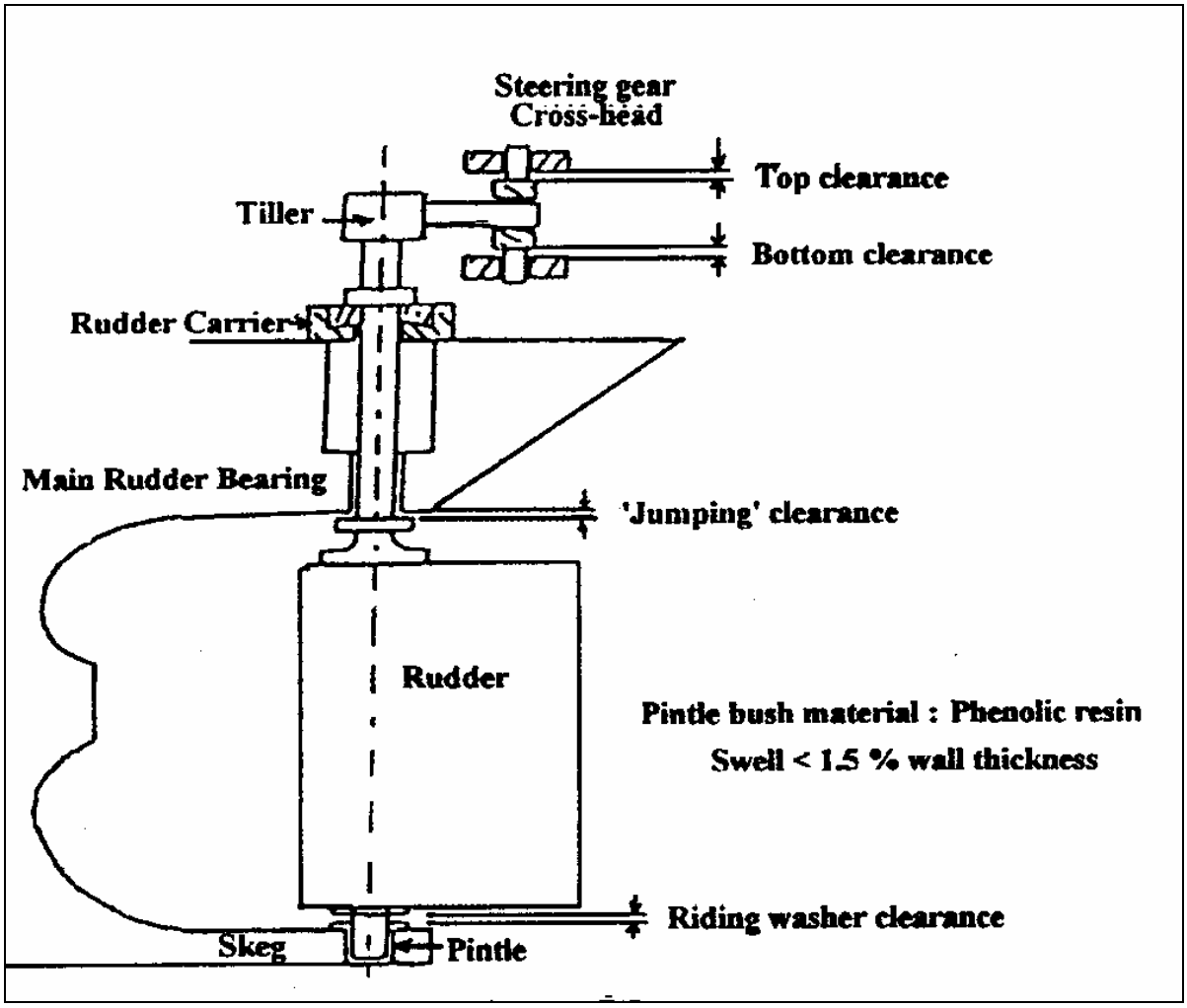
5) Remain in this condition for several hours (says overnight) and turn engine by Turning Gear to change the shaft position 3 - 4 times

6) Check oil leakage from Drain Plug, harder tank and if it is all right, fit back Drain Plug and fill oil from venting and filing plug and close

7) Forward seal is fitted

RUDDER CLEARANCES

The sketch below shows the principle clearance checked during Docking.



Rudder clearances

- The steering gear Cross-head top clearance must be substantially greater then the 'Jumping' clearance, so as to prevent any bending moment from damaging the steering gear, in the event of running aground.
- The Steering gear Cross-head bottom clearance should be sufficient to cater for wear in the Rudder Carrier bearing, which could otherwise affect the movement of the rams. This bottom clearance should be substantially greater than the Riding washer clearance.
- Confirm that the bottom Clearance is reducing, to verify downward displacement, over a period of time.
- The Steering gear Cross-head top and bottom clearances are of the order of 20 – 25 mm for small to medium size vessels.
- Insufficient Riding washer clearance would lead to wear of the carrier bearing. There should be no keel blocks in way of the Skeg.

Stern tube seal leakage

Cause

The stern tube seal leakage can be caused by

1. Misalignment of bushes.
2. Poor seal material and design.
3. Liner material weakness.
4. Fishing line or similar material entering into the seal.
5. Electro static pitting due to an unsatisfactory shafting earthing device.
6. Operating at a reduced R.P.M for prolong time, at which a hydrodynamic oil film would not be established.
7. Contaminated oil supply with grit, dirt welding slag etc:. this scores the liner and rips the rubber seal.
8. Wear of the seals or loss of tension in greater spring.
9. Rubber seal damage at high temperature, cracking and hardening.
10. Distortion and rupture due to excessive pressure difference.

Remedy

This defect can be remedy by

1. Made sure alignment for of bushes.
2. Used superior material and an improve lip profile for seal.
3. Ceramic coating applied to the stern tube liner at lip running surface.
4. The design of rope guard should as far as practicable to prevent this happening.
5. Keep always-good condition in earthing device.
6. Avoid operating at the reduced R.P.M for prolong time.

Rate of leakage is depend on

1. It is a function of the relative pressure head between header tank oil level and sea water level.
2. Depend on the effective area of the leakage.
3. Viscosity of a oil.

To continued the voyage

(a) Loss of oil

The serious oil leakage from aft seal can be minimize and to continued the voyage by

1. Tip the vessel to certain allowable trim.
2. Use more viscous oil (e.g. cylinder oil).
3. Reduced the oil pressure head by introducing a temporary header tank, normally in the form of a 200 Lit oil drum connected to the system by a flexible hose. The drum can be arranged in such a vertical position. That only a slight pressure head is exerted.
4. In large vessel, lower header tank can be used instead.
5. Reduced R.P.M if required to avoid boundary lubrication.

(b) Ingress of sea water

Indicated by emulsification of lubricant.

1. Use higher oil header tank.
2. Slow down the shaft revolution

To repair at port

Following repair can be done in port if no dry dock facilities will available, also stern tube seal capable of being split in a longitudinal direction having in news, enable all the sealing ring to be renew. When the vessel is sufficient tip to raise the astern out of the water.

If due for a scheduled for dry-docking or dry dock facilities will available, arrange a dry dock and renew the all seal.

To claim for insurance

When leakage was occur, arrive to port inform the master of the vessel negotiate with the chatterer, arrange both classification surveyor and under writer surveyor will invite on board to survey and to witness the damage through agent.

After surveying found that, stern tube liner was misaligning due to the last recent dry dock's labours error. So we have to arrange the claim for insurance.

In the mean time, contact shore repair firm and ask them to submit the quotation for repair under the classification surveyor instruction, the method of repair as per G.L rules and requirement.

When calculating for insurance claim cost, including the repair labor charge, spare parts cost, port stay charge, ship labor cost, cargo delay cost, etc. but not including the transportation cost.

ENGINE OPERATIONAL FAULTS

Causes of High exhaust temperature at all unit

Factor contributing to increase exhaust temperature are

- ⇨ High Scavenge air temperature (Air cooler fouling, Ambient climate condition)
- ⇨ Fouling of air and gas passages
- ⇨ Fouling of T/C
- ⇨ Wrong camshaft position (faulting timing of fuel pump & exhaust valve) [incomplete combustion, after burning]
- ⇨ Wear of Fuel Cam and Exhaust Cam
- ⇨ Bad fuel quality
- ⇨ Inadequate FO purification
- ⇨ Overloading (such as hull fouling, propeller blade bending)

High exhaust temperature for one cylinder

- ⇨ Faulty fuel valve & fuel pump (poor atomization, late injection, after burning, or incorrect timing of this unit)
- ⇨ Leaky exhaust valve
- ⇨ Scavenge fire in this unit
- ⇨ Blow pass Wrong adjustment and damaged cam
- ⇨ Insufficient cooling water to this unit

Cause of decrease exhaust temperature on one unit

- ☞ Air in fuel valve
- ☞ Faulty fuel valve (ie. Needle valve lifts too low)
- ☞ Defective suction valve in fuel pump
- ☞ Fuel pump plunger sticking or leaking

Smoky Exhaust

- ☞ Overload Defective fuel valve
- ☞ Scavenge fire
- ☞ After burning
- ☞ Unstable fuel
- ☞ Insufficient air supply
- ☞ TC rpm not corresponding with engine rpm

Colour of Exhaust

- ⇨ Blue ⇨ Excess cylinder oil, leak of oil cooled piston
- ⇨ White ⇨ Excess water and air, one unit misfire
- ⇨ Black ⇨ More fuel, fuel valve leak, ignition too late
- ⇨ Yellow ⇨ High Sulphur content (Normal 1 – 1.5%)
- ⇨ Colourless ⇨ Good

What point do you check when engine is smoky ?

To check

1) Fuel temp

2) Charge air temperature & pressure check (by light spring card)
3) Suction air filter is dirty or choke
4) Check fuel valve

What should be carried out ?

To be taken draw card & evaluated the combustion pressure.

Engine overload indication

- Speed drop
- High exhaust temperature at same rpm
- More fuel consumption

Causes of engine overload

- **?** Hull fouling (caused by marine growth)
- **?** Propeller damaged
- **?** Shallow water
- **?** Heavy weather

Cause of excessive noise from crankcase

1) Slack chain (or) worn gear
2) Knocking from slack bearing
3) Slacken or break bolts, studs
4) Engine overload
5) Lubrication fault (insufficient oil pressure, poor quality, chock oil passage, failure of oil pipe)
6) Piston ring blow pass

Cause of M/E speed reduce on the way (Ship's speed slowdown)

Cause ☞ Improper combustion of ME

1) Seized or leaky fuel pump plunger
2) Sticking fuel valve spindle
3) Burst fuel delivery pipe
4) Choked fuel line filter
5) Choked air inlet filter
6) Water in fuel oil
7) Overloading of engine
  a. Fouling of propeller
  b. Increased propeller slip due to heavy weather
8) In case of scavenge fire

Remedies

1) Take all Indicator cards
2) To consider the developed power
3) Evaluate combustion and expansion process, Pmax and Pcamp from out of phase diagram
4) Check cylinder tightness
5) Evaluate exhausting and scavenging process from light spring diagram
6) Defects found should be rectified as soon as possible

Why causes that engine start with air but no turn ?

1. Air pressure low
2. Faulty open of valve / stop valve/ bottle isolating valve to distributor
3. Turning engage (Turning gear inter lock)
4. L.O pump not starting.

Why causes that engine not ignite but engine turn ?

1. Governor tip (over speed trip)
2. Fuel system fault (Settling & service tank no Oil / F.O pump not start)
3. Air pressure low & so compression pressure low
4. Air in fuel pump, pipe line or Fuel valve
5. Incorrect air staring timing.

How would you investigate and find the cause of an engine cannot start ?

If air line is Ok or not,

1. Insufficient air pressure
2. Air staring valve sticking
3. System air lock
4. Defective distributor
5. Water in fuel
6. Fuel line air lock
7. Defective nozzle
8. Too late fuel timing (faulty fuel pump)
9. Poor compression
10. Lack of scavenge air
11. L.O low temperature
12. Safety interlock.

Action when engine cannot start

1. Inform to bridge
2. Check the air bottle
3. Check inter lock system (Turning gear, L.O, JKT FW, F.O pressure) and telegraph position.
4. If no rotation of flywheel when starting check starting air system (automatic air staring valve, air distributor, air staring valve, linkage of air staring mechanism)
5. If rotation of flywheel when starting, check fuel system.
6. Due to poor combustion, lack of scavenge air, too late fuel pump timing, fuel line air lack defective nozzle.

Special care during reduce speed

01) Increase cylinder oil.
02) If necessary change H.O to DO.
03) If necessary, run auxiliary blower.
04) Check temperature & pressure of L.O, F.W & scavenge air.
05) Check exhaust smoke & temperature.

Drop of Engine Speed

Causes for the trouble that the engine speed, in some cases, drops during operation in spite of the correct position.

01. Increase in the resistance of ship's hull
02. Propeller damaged.
03. Sailing in shallow water
04. Change in the centerline of the shafting increased resistance.
05. Air / gas / steam remains in the fuel injection pump or in the fuel line. *In the case, open the air vent valve, which is used for priming, and remove the air from the fuel oil lines*
06. Fuel oil includes water; *Wastewater should be removed form the service tank at regular intervals, or to be separated by means of the purifier.*
07. Improper fuel quality.
08. *Defective fuel valves(s) or fuel pump(s)*
8a) Unsatisfactory functioning of the fuel injection valve.
8b) Insufficient pressure of the fuel injection pumps suction
8c) Abnormality of the fuel adjusting links device.
09. *Oil pressure before fuel pumps too low.*
9a) The fuel oil strainer is clogged or damaged.
9b) Insufficient supply of fuel oil due to unsatisfactory functioning of the fuel oil flow meter
10. The governor is sticking at the position of low engine speed.
11. Overheating of the moving parts .The engine should be stopped immediately
12. Unsatisfactory functioning of the exhaust valve and the dirty scavenge ports
13. A fire occurs in the scavenge chamber and air is insufficient. The engine must be stopped immediately
14. The turbocharger of the air cooler is dirty or damaged.
15. Slow down or shut down. *Check pressure and temperature levels. If these are in order, check for faults in the slow down equipment.*

Remedies

7) Take all Indicator cards
8) To consider the developed power
9) Evaluate combustion and expansion process, Pmax and Pcamp from out of phase diagram
10) Check cylinder tightness
11) Evaluate exhausting and scavenging process from light spring diagram
12) Defects found should be rectified as soon as possible

Sudden Stopping of Engine:

Causes for unexpected stop of the engine are as follows:

01. Drop of the system lubricating oil pressure and the turbocharger lub oil pressure actuates the emergency stop device.
02. The fuel oil supply to the fuel injection pump is shut of f by the causes of the stop of fuel circulating pump or fuel oil service tank is empty.
03. The fuel injection pump rack was pulled back suddenly to "0" position due to governor trouble.
04. When continuous fuel injection failed due to damage of the fuel oil line.
05. When the exhaust valve driving parts or the exhaust gas passages were damaged and gas discharge from the cylinder was troubled
06. Turbocharger is damaged.

Impossible of Reversing

If the camshaft does not move to the reversing position even the operation is made for Reversing causes for such impossible of reversing are considered as follows:

01. The start / stop lever is not in the stop position
02. The main engine speed is not under the speed enabling for reversing.
03. The valve on the starting air reservoir or air line is closed.

04. The valves on the control system control air line are sticked.
05. The pressure of the control system control air line is too low
06. The starting air pressure is too low

UEC 50 LSH

07. The stopper of the safety device for camshaft shifting gear is slicked.
08. Oil amount in the reversing oil bottles of the camshaft shifting gear is insufficient
09. The reversing pilot valve is not operational because of poor adjustment of the reverse handle.

Abnormal Explosion on Starting

Since cause for the abnormal firing on the engine staring are considered as follows, take care sufficiently at inspection before the starting, and at inspection and maintenance for the parts in question.

01. The manoeuvring handle position is too much increased and fuel is injected excessively.
02. Oil is remaining on the top of the piston head from the beginning.
03. Incorrect adjustment of the fuel injection n valve namely, insufficient opening pressure.
04. Insufficient facing up of the fuel injection valve nozzle and needle valve.
05. Incorrect setting of the fuel injection pumps rack and fuel injection timing.
06. Incorrect setting of the linkage between handle and governor
07. Incorrect setting of the governor
08. Due to sticking of the fuel injection pump delivery valve, the presence of foreign matters and incorrect facing up of the valve, fuel oil flows into the fuel injection valve too early and too long

❖ *In the following case, open the indicator valves of all cylinders and the engine should be operated by means of starting air only slightly longer and blow off the fuel.*

a) In priming operation of the fuel oil injection line, the fuel oil entered on the piston head.
b) When the fuel injection valve is dismantled, fuel oil entered on the piston head.
c) Due to failure and repetition of starting operation, fuel oil injection in previous operation still remained on the piston head.

Knocking in Engine

The knocking and noise, during the engine operations caused by the engine trouble. The noise due to the knocking in the engine is, in many cases, produced by the loosened moving parts, early ignition and uneven load distribution among carried by the cylinders. It is very difficult to detect the noise by hearing.

If the noise is due to early ignition or due to uneven load distribution among the cylinders, fuel oil of the cylinder in question can be cut as an emergency measure. It can be early detected through the indicator diagram of the cylinder in question where the noise comes from ignition timing and uneven load distribution among the cylinder.

1. In case of early ignition, the following things are considered.
  a) Leakage in the fuel injection valve or poor its spring pressure.
  b) Incorrect adjusting of the fuel injection pump.
  c) A large amount of low viscosity oil mixed in fuel oil.
2. In case of uneven load distribution among the cylinders, the following things are considered.
  a) Incorrect adjustment of the fuel injection pump
  b) Incorrect adjustment of the fuel adjusting links.

Diesel knock ~ Due to rapid burning of the charge of fuel oil accumulated during the delay period between the time of injection & ignition.

Cause of excessive noise from crankcase

7) Slack chain (or) worn gear
8) Knocking from slack bearing
9) Slacken or break bolts, studs

10) Engine overload
11) Lubrication fault (insufficient oil pressure, poor quality, chock oil passage, failure of oil pipe)
12) Piston ring blow pass

Rise in Exhaust Gas Temperature

The exhaust gas temperature rise has a great effect on the life on the exhaust valve and also on the wear of the piston ring and cylinder liner. The causes for exhaust gas temperature rise are considered as follow.

All cylinders

1. Increased in engine load.
1a) The fouling and deformation of the ship's hull increases resistance to a fairly great extent, liable to increase engine load.
1b) Bending of propeller blades due to drifting woods and going ground subjects the engine to an increased load.
2. Fouling of scavenge air passage
2a) Fouling of airside due to oil mist on suction casing and diffuser of the turbocharger
2b) Clogging of cylinder liner scavenge port by combustion products.
3. Fouling of exhaust gas passage.
3a) Combustion products stick to the turbocharger nozzles and the surface of turbine blades, thus clogging the exhaust gas passage and reducing the turbocharger efficiency.
3b) Failure of nozzles and blades of turbocharger caused by foreign materials results the reduction in the turbine efficiency.
4. Leakage of scavenging air
5. Insufficient suction air
6. Increased scavenge air temperature owing to in adequate air cooler function.
7. Inadequate fuel oil cleaning, or altered combustion characteristics of fuel.
8. Wrong position of camshaft (maladjusted or defective chain drive)
9. Wear of Fuel Cam and Exhaust Cam

Single Cylinder

1. Defective fuel valves, or fuel nozzles.
a) Due to the enlarged nozzle hole of the fuel injection valve, which was used for a long period of time?
1. Blow by in combustion chamber (A fire occurs in the scavenging chamber and air is insufficient)
2. The scavenging valve in the scavenging air trunk is damaged or opening and closing function of scavenging valve is not good.
3. Leaking exhaust valve.
4. Wrongly adjusted, or slipped, fuel cam (Check the fuel pump lead) (B&W)
5. Abnormal exhaust gas temperature or pressure in cylinder.
a) Exhaust valve closing timing is deviated due to clogging of orifice off exhaust valve driving gear, usually accompanying with a slight water-hammering of exhaust valve driving oil and causes deviation of exhaust gas temperature and pressure in the cylinder. (UEC)

Blow by of Exhaust Valve

If the following phenomena are observed during operation, damage of exhaust valve shall be doubted. Quickly stop the engine, dismantle the susceptible exhaust valve, make inspection and repair it or replace parts with spare ones if necessary.

1) Rise in exhaust gas temperature
2) Abnormality of compression pressure
3) Noise
4) Abnormal Pressure of cooling water pump.

Blow-Past

- **a** Blow- past is the term used when combustion gases at high temperature leak past the piston between the piston rings and cylinder liner.
- **a** Blow-past causes rapid local overheating, removing the lub oil film and causing further damage to the surfaces and possible piston seizure.
- **a** In tow stroke engines, burning gases will enter scavenge spaces causing fouling, overheating and even scavenge fires.
- **a** In four stroke engines, these gases will enter the crankcase with sever risk of a crankcase explosion

Causes of blow-past:

- ⇨ Excessive cylinder liner wears.
- ⇨ Lack of cylinder lubrication
- ⇨ Worn, broken, stuck or poorly maintained piston rings.
- ⇨ Worn piston ring groove landings allowing rings to cant and jam
- ⇨ Carbon jamming rings in grooves.

Remedy of blow-past

- 🛠 Gauge the cylinder liner and renew if necessary
- 🛠 Overhaul piston
- 🛠 Clean piston ring grooves and gauge them
- 🛠 Machine or fit new groove inserts as necessary
- 🛠 Renew piston rings with correct clearances
- 🛠 Maintain cylinder lubrication and avoid overload.

'

When all unit scavenge fire broken out.

- Engine power balance.
- Timing checking.
- Took indicator diagram.

Surging in Turbocharger

In case surging occurs in the turbocharger while the engine is in service, generally the following causes may be considered as reasons for such surging:

1) Rapid change in load ☞ Sudden fluctuation in rough weather or at the time of crash astern running.
2) Insufficient supply of fuel ☞ Due to clogging of strainers and incorrect adjustment of the circulating pump pressure
3) Abnormally of fuel system ☞ Due to sticking of fuel injection pump, damaged high-pressure pipe or the failure of plunger barrel.
4) Narrowed scavenging air passage ☞ Due to pronounced fouling on the top surface of the air cooler.
5) Narrowed exhaust gas passage ☞ Increase in the resistance of the exhaust gas discharging passages
6) Engine operation at overload ☞ Due to fouling of ship's hull or damage of propeller.
7) Failure of turbine blade, nozzle or diffuser ☞ Turbine blade, nozzles or diffuser is remarkably fouled or damaged unexpectedly when they are opened for repair.
8) Increased air resistance ☞ The turbocharger suction filter is extremely dirty, or there is a great air resistance due to a small piece of cloth and vinyl etc. adhering to the filter surface.

Power Balancing of Engine

- ✱ For economy and efficient running of an engine equal power should be produced from each cylinder. This is then said to be power balanced and it may be necessary to make some minor adjustments to achieve this.
- ✱ Power produced is related to the quantity of fuel injected and balancing is carried out by small adjustment to individual fuel pump controls.

- ❋ Adjustments are limited to ensure units are not overloaded, exhaust temperatures are not excessive and that pump control still cut of f when brought to stop.
- ❋ Fuel pump rack positions and exhaust & cooling outlet temperatures from each cylinder should be noted.
- ❋ Equal exhaust temperatures on their do not necessarily show an accurate balance.
- ❋ Power balance can be checked by measurement from indicator diagrams by calculating the area or mean height form each cylinder.
- ❋ If an engines operates in an unbalanced conditions, some bearings and running gear may become overloaded; this may cause overheating and bearing failure.
- ❋ Overloaded in cylinder may cause piston blow past, with the corresponding dangers of overheated / seized piston.
- ❋ Unbalance will also set up vibrations which, if maintained for prolonged periods, will cause fatigue from the fluctuating stress induced. This may in turn lead to fatigue cracking of metal in bearings , fracture in bearings studs or bolts, cracks in crankshaft and bedplate, and slackening or failure of holding down bolts.
- ❋ For proper power balance, engine running condition should be normal by observation of the relevant temperature & pressure, particularly exhaust and cooling outlet temperatures, lubricating oil and turbocharger pressures. The exhaust should be clear of smoke and there should be no unusual noise or vibration.

What do you understand by the terms 'interlocks' and 'blocking devices' in starting and reversing mechanisms?

Interlocks and blocking devices are provided so that the engine can be started or reversed only after certain conditions have been fulfilled. The starting interlocks prevent the engine being put on to fuel before all the sequences of the starting system have been completed. During the reversing of engines the interlocks ensure that the reversing mechanism and gear have completed all operations before air can be put on to the starting valves, thus preventing the engine from starting with the wrong direction of rotation.

The construction of the interlocks in the starting and reversing gear varies considerably between different designs of engines. With systems controlled by the operation of hand levers, the interlocks may be cams or pins which lock and prevent hand-lever movement. In engines started by hand-wheel controls, the interlocks are often slotted discs (fitted on the wheel shafts) and small levers which engage or clear the slots in the discs.

Blocking devices are mechanical, pneumatic, electrical or hydraulic devices used to make for safer operation of the engine. Some engines have a blocking device connected with the ship's engine room telegraph which prevents the engine being put astern when an ahead order is given, and vice versa. In other engines, blocking devices are fitted to the engine turning gear so that the engine cannot be inadvertently started with the turning gear in.

Why is it important to know how the interlocks and blocking devices operate on an engine over which you have control?

When fuel-valve or fuel-pump timing is being checked the interlock devices must be cleared so that the fuel lever can be put into the position at which the timing is checked. Similarly the fuel lever must be put into various fuel-setting positions when the cut-off points on certain types of fuel pumps are being checked.

In the event of engine-room telegraph failure, any interlocking and blocking devices operated from the telegraph would prevent the engine being manoeuvred during this time of emergency. It is therefore important to know how the interlock and blocking devices may be overridden so that the engine can be manoeuvred under emergency conditions with orders via the bridge to engine-room telephone.

Note The instruction books from the engine builder give details of the interlocks on engine starting and reversing systems; sometimes the engine telegraph interlock details are covered in the engine instruction book and sometimes in the engine-room telegraph instruction book.

MAINTAING GOOD ENGINE PERFORMANCE.

1. Check exhausts smoke & sound.
2. Check exhaust temperature & engine running parameters.
3. Perform regular maintenance works & damage repair.
4. Engine can be run with rated speed.
5. Took indicator diagram & perform power balancing.

Balancing of engine.

Reducing, eliminating and minimizing of the vibration.
The forces which causes vibration are

1. Inertia force.
2. Gas force.
3. Spring force.
4. Damping force.

Balancing is a way of controlling vibration by arranging that the overall summation of the out of balance forces and couples cancels out or is reduced to a more acceptable amount.

Engine balancing.

Engine balance can only be achieved by correcting values in the following order.
Compression pressure; Crank angle at Pmax point; Pmax; Expansion pressure; Fuel pump index; Exhaust gas temperature.

Static Balance.

When C.G of the shaft coincide on the polar axis of its journal, it is said that the system in a static balance.

Dynamic Balance.

With the static balance condition in the presence, additionally when the shaft is revolved, the load on each bearing must remain constant trough out 360' rotation.

Methods of reversing.

1) Direct reversal of the engine.

(a) cam shift axially (b) cam shift angularly

2) Controllable pitch propeller.
3) Diesel electric system. - Engine and electric generator run in a constant direction, supplying power to a reversible electric motor.

4) Reverse gear and clutch.

Couples.

It can be defined as a pair of forces of equal magnitude acting in parallel but opposite in direction.

Ship vibration.

1. Synchronous or resonance vibration due to main & auxiliary machinery.(critical speed)
2. Local vibration (small portion of hull structure such as bulkhead, brackets)
3. Vibration due to external source.
   (a) Propeller unbalance
   (b) Environment of ship.

To reduce vibration.

Detuner (forward flexible flywheel) Vibration damper. (e.g. magnetic slip, coupling spring & centrifugal friction coupling.)

Aft side no need because of thrust block, it can absorb vibration.

Causes of propeller vibration.

1. Excessive clearance of stern tube.
2. Misalignment of propeller shaft.
3. Due to shallow water effect.
4. Propeller blade unbalance.

Barred speed range

Engine running with critical speed condition with severe vibration at barred speed range.

Working stroke of various pistons synchronized with one of the natural frequencies of the crank shaft.

Produce resonance condition & severe vibration.

Sound rough, at mid-stroke the torsional oscillation of the cranks with biggest amplitude, longitudinal vibration of connecting rod, lateral vibration of piston & entablature.

Difficult to control the possible critical and where vibration is too dangerous for continuous operation.

How will you notice your engine overload?

- Fuel rack, T/C rpm, exhausts temperature.

Cause of excessive load - Sea condition, Wind condition, Hull fouling, Shallow water, Propeller unbalance.

Increase fuel consumption (suddenly)

Loading condition, Trim & list, Wind & sea condition, Hull fouling, Propeller unbalance, Check dry docking interval, Leakage of fuel oil system.

Engine performance curve.

Engine maker usually provided Performance curve which contain compression pressure, max: efficiency peak pressure, T/C rpm, exhaust temperature, scavenge air pressure, engine rpm, S.F.O.C etc: in relation to engine load.

BUNKER SPECIFICATION
F.O SPECIFICATION

Atypical fuel specification for main propulsion marine engine:

SG at 15C calculation, choice of gravity disc.

Density	- 991 Kg/m^3 (max), usually measured at 15 °C
Viscosity	- 700 Cst at 50 °C (max) Correct heating temperature for end (10 ~ 14 Cst) heater, handling, preheating and centrifuging
Flash Point	- 60 °C (min) for maximum storage tank heating temperature, fire risk factor
Pour point	- solidification in tanks and pipelines
Carbon content residue (CCR)	- fouling of gas ways and piston rings
Conradson carbon	- 22% by weight (max)
Asphalt	- 14% by weight (max)
Sulphur	- 5% by weight (max)
Water	- 1% by weight or volume (max) sodium content of salt water
Cetane number	- for distillate fuels: measure of ignition quality
Ash	- 0.2% by weight (max), abrasion
Aluminium	- 30 mg/Kg (max)
Vanadium	- 600 mg/Kg (max), undesirable by itself, but when present with sodium, leads to exhaust valve corrosion, cylinder and turbocharger despots, which can cause overheating and failure. A mass ratio of 1:3 of Na:Va can be troublesome, especially with high vanadium content.
Sodium	- 30% of the Vanadium content

- Name of vessel
- Port of delivery
- Date of Bunker
- Bunker operation time (Duration)
- Temperature of product

As a C/E checking for bunker receipt

1. **Viscosity** {Engine inlet temperature setting}
2. **Quantity**
3. **Specific gravity** {Calculation and purifier gravity disk and temperature selection}
4. **Bunker barge temperature** {calculation for bunker receipt}
5. **Pour point** {Maintain temperature at D.B tank and transferring}
6. **Flash point** {Maintain temperature at settling and service tank}
7. **Water, sulphur and other impurities check**.

Calculation of bunker receipt.

The specific gravity of fuel oil change in relation with temperature change. So the bunker barge temperature must be considered to correct the actual specific gravity to calculate the correct amount of fuel.

$$SG_T = SG_{15} - 0.00064\ (T - 15)'C$$

Bunker sample taking method.

1. Continuous dripping.
2. Spot check. (a) Random check from bunker barge tank
   (b) Random check from bunker pipe.

How to order bunker at next port as C/E.

- Took the essential data from Master.
- Distance & average speed estimated.
- To estimate steaming time, river passage, pilotage, anchorage, port staying time.
- To estimate HO & DO consumption. (Running hours of M/E, G/E & Boiler.)

- ✔ Estimate Trim & Heel condition.
- ✔ Environmental condition such as weather, current.
- ✔ + 3 days reserve.
- ✔ Check R.O.B.
- ✔ Amount, Type of fuel, Viscosity are gave for bunker requisition.

As a C/E when bunkering.

1. Safety 2. Pollution 3. Stability & 4. Calculation.
If possible, the bunker oil does not mix with other fuel oil.

After taking bad fuel oil

a Protest through head office.
a Check engine performance.
a Check purifier.

S & D Daily Fuel Oil Settling and Service Tanks Requirements

For fuel oil settling tank low/high level alarm and service tank low level alarm

- F.O low temperature alarm and heater on
- F.O high temperature alarm and heater off
- F.O transfer pump cut on / cut out device

(01) Filling line with a valve of Gate or Sluice type.
(02) Supply lines to the engines and boilers with quick closing valves.
(03) Sounding pipe is with a gas tight cap. A striker plate of a quarter inch per a half inch thick is welded under this pipe to prevent wear of the tank bottom by sounding sticks.
(04) A remote reading gauge, pneumercator gauge or a gauge glass, fit to give a visual reading. If gauge glass is fitted, the bottom gauge cock should be of self-closing type to prevent escape of oil should the glass break.
(05) Vent pipe, 25% more area than the filling pipe, with a flame trap of copper wire gauze, 28 squares per square inch.
(06) An overflow pipe with a sight glass, leading to overflow tank, to prevent spreading out of oil from the vent when the tank is overfilled.
(07) Steam heating coils heating surface area 0.5 square feet per ton of oil, is fitted by means of which the temperature of the oil will be raised to at least 50 C, to reduce its viscosity, and to facilitate the process of separation.
(08) A thermometer pocket to insert thermometer to record the temperature of the tank contact.
(09) A drain valve of self-closing type at the tank bottom to draw off sludges and water.
(10) A dumping valve of self-closing type to drain down the whole capacity into the double bottom tanks in case of fire in the vicinity.
(11) Two manhole doors, one on the top other on the side, about two feet from the tank bottom.

One unit of main engine blanking up procedure.

(01) Check the damage condition of the engine.
(02) Cut off fuel supply to effected cylinder by lifting the plunger with roller of fuel injection pump.
(03) Blank up starting air pipe, nozzle-cooling pipe.
(04) When piston is took out or hang up by hanging bar, exhaust valve is locked at closed position by taking out push rod and lift up the rocker arm.
(05) Piston with piston rod and crosshead is took out or hang up by hanging bar.
(06) If piston with piston rod is took out blank off the stuffing box opening with two plates. (towards scavenging air box and crankcase). Minimum plate thickness 5mm.
(07) Took out connecting rod and crank bearing.
(08) Blank off the oil inlet from telescopic pipe.
(09) Put cylinder out of operation.
(10) Run the engine with minimum vibration condition.

Fuel oil treatment.

1. Fuel oil sample sent to laboratory.
2. DB tank →Dose Fuel Oil Treatment.

→Maintain temperature 10'C above poor point to prevent formation of sludge & pumping.

3. Frequent cleaning of transfer pump suction filter.
4. Settling tank →Maintain temperature at least 14'C below flash point.
   →Drain out water & sludge.
5. Purifier →clean suction strainer
   →Temperature & gravity disc selection. (S.G)
6. Service tank →Maintain temperature at least 14'C below flash point.
   →Drain out water & sludge.
   →Chemical dose. (For improve combustion)
7. Engine inlet temperature setting depending upon required viscosity.
8. Check engine performance.

Waste Heat Recovery System.

Turbocharger, Exhaust gas economizer, Fresh water generator, Jacket heating system, boiler feed water heating system & Turbo compounding system.
Modern 2 stroke cycle, slow speed, long stroke engine

- Shaft propelling 52%
- Heat loss to cooling service 19%
- Heat loss to exhaust
  Recovered by E.G.E 14%
  Loss with gas 14%
- Radiation loss 1%

Closed pressurized mixing tube.

1. Expel vapor.
2. Prevent foaming.
3. Sludge & water can be drain out.
4. Temperature maintain.

Marine Machineries

Marine machineries are designed to operate when the ship is upright and when inclined at any angle of list up to and including 15° either way under static conditions and 22.5° under dynamic conditions (rolling) either way and simultaneously inclined dynamically (pitching) 7.5° by bow or stern.
(SOLAS 74/78)

With reference to main engine using poor H.O

1. How the impurities attack the machinery parts.

a) Water

More than 1% may cause

01. Corrosion
02. Poor atomization and poor combustion
03. Emulsification of fuel leading to sludge formation
04. Seizure of fuel pump and fuel valve
05. Misfiring of engine
06. Surging of turbocharger
07. Stopping of engine in extreme case
08. Natural L.O film can be removed
09. Promotion of microbial degradation
10. Difficulty in separation of fuel
11. Foaming of fuel in mixing tube.

b) Sludge

Sludge may cause

01. Instability of fuels
02. Incompatibility of fuel
03. Blockage of filters and pipe lines

04. Upsetting centrifuge's operation
Dosage sludge conditioner.

c) Asphaltenes

01. Blockage of filters and pipe lines.
02. Upsetting centrifuge's operation
03. Fouling of combustion chamber and scavenge space
04. Black smoke emission
05. Trumpets or Petal formation of nozzle

Proper treatment with a special asphaltenes dispersant.

d) Conradson carbon residue [C.C.R]

It may cause unburned carbon deposits and smoke emission has been increased with high C.C.R value.

C.C.R value over 10% will cause fouling of combustion chamber and scavenge space. Further more resulting smoky emission and trumpet formation at nozzle.

e) Sulphur

It may cause low temperature corrosion or acid corrosion or acid corrosion.
To combat the acid effect when burning high Sulphur fuels.

In combustion, sulphur tends to decrease calorific value of fuel, each 1% of sulphur causing

0.7% of C.V to be lost.

f) Ash {Vanadium, Sodium, Aluminum, Nickel, Silicon, Sand}

May cause hot corrosion during combustion these contaminants are chemically combined with the fuel and can not be removed by centrifuging alone they are highly abrasive particles and abrasion occur between liner and piston, fuel pump, fuel valve.

Hot corrosion, especially by vanadium and sodium highly corrosive in liquid state. These motten compounds at temperature (480~560), adhere especially to the exhaust valve surface and dissolve the protecting coating.

The corrosive flux of sodium vanadal will also attack turbine blades and leading to unbalance system and blockage of the nozzle rings.

The also attack high-pressure boiler and super heaters especially at the fireside.

g) Catfins

Having highly abrasive characteristic which cause serious wears and scratching an fine running engine's components, cylinder liner and piston, fuel pump plungers and fuel valves.

The small particles being the most trouble some since they are settle out less easily and passed through filters.

h) Microbial degradation of distillate fuel

Degradation of micro organisms show themselves by smell, clogging of filters frequently creation of sludge and development of slimy build up in tank's surface.

Factor govern the ignition

Water: poor combustion, poor atomization, injection viscosity increase. It cause late injection and combustion

Sulphur: lost of calorific value, thermal efficiency reduce, late injection and combustion

Asphaltene: trumpet or petal formation at nozzle the smaller the size the greater their readiness to burn in a short time, extant passage choking. Late combustion.

C.C.R: Unburned carbon deposits ring zone and trumpet formation, lost of compression duet to damage gas sealing, it cause late combustion.

Cetane No: high cetain number, shorter time between fuel injection and rapid combustion, better ignition quality, early combustion.

Viscosity: injection viscosity at nozzle, low viscosity cause early injection and combustion.

Bad fuel oil.
Action after taking.

01. Invite bunker surveyor.
02. Frequent cleaning of F.O filters.
03. Fuel oil sample sent to laboratory.
04. DB tank - Dose Fuel Oil Treatment.
05. Maintain temperature 10'C above poor point to prevent formation of sludge & pumping.
06. Frequent cleaning of transfer pump suction filter.
07. Settling tank - Maintain temperature at least 14'C below flash point.
    - Drain out water & sludge.
08. Purifier - Run F.O purifier 2 numbers parallel with for each 50% slow through put.
    - Temperature & gravity disc selection. (S.G)
09. Service tank - Maintain temperature at least 14'C below flash point.
    - Drain out water & sludge.
10. Chemical dose. (For improve combustion)
11. Engine inlet temperature setting depending upon required viscosity.
12. Check and record engine performance.

Effect.

1. Impurities attack to Machinery parts.
2. Hot corrosion, cold corrosion, trumpet formation.
3. Fuel oil filters chocking.

Automatic system control.

1. Electronic
2. Electro hydraulic
3. Electro pneumatic
4. Pneumatic.

Self closing Valve

Where self closing type valve are fitted and why these are fitted ?

It is fitted dumping valve and drain valve of settling tank and service tank.

To prevent changing of working position (accidentally opened & human error) due to ship rolling and vibration.

Where fitted back pressure valve ?

High temperature setting room evaporator outlet before collecting point.

Quick closing Valve

Quick closing valve are fitted at outlet of settling and service tank to engine, G.E and boiler and on some L.O tank.

They are also fitted on the fuel oil transfer pump suction from the double bottom tank.

It can be closed from remote position in case of fire in engine room or emergency.

What are the function of feed check valve ?

They are non return valve. They are used to allow feed the water into the boiler by feed pump and to prevent back flow of water.

Safety valve

- ✔ Fully open at set pressure
- ✔ Close at set pressure
- ✔ Relieve excess pressure
- ✔ Can open manually
- ✔ Setting pressure not more than 3% above approve working pressure.

Spare gears
1. If 3 G.E 1 complete set of generator.
2. 1 unit set of M.E.
1. M.E one cylinder cover complete, one additional seat of valves for one cylinder,
2. Exhaust valve - 1/2 no: of cylinder.
3. Fuel valve - complete set with spring & fitting of 1/2 of cylinder.
4. Cylinder liner - 1 complete set.
5. One set of cylinder liner joints for engine.
6. One piston.

SHAFT GENERATOR

What is the shaft generator ?

It is an alternator which is driven by main propulsion propeller shaft through clutch and gearing, especially those sailing for long period at constant ship speed.
It can be used at sea when M/E is running o full speed. It is capable for load

Lloyd's Requirements

1) Lloyd's register would regard a shaft generator as a service main generator, if ME is intended to operate at constant speed (CPP)
2) If ME does not operate at constant speed, shaft generator would be disregarded as a service main generator, and at last 2 other independent generators would be required

Running condition

1) Full generator capacity is available within 60 ~ 100 % of normal speed
2) More suitable for shaft with CPP, (constant shaft sped and variable blade pitch)

Advantages of shaft generator

01) Saving in fuel cost is main advantage
02) Saving in LO consumption, repair and maintenance cost due to reduced main generator's running hours
03) Reduction in noise, space and weight, capital saving by reduction of numbers and ratings of main generators

Disadvantages

01) Reduction in ship speed
02) Problems can rise to maintain electrical supply, during emergency manoeuvring astern
03) Increase in capital cost

ME driven generator

01) Fuel consumption is saved
02) Lower running and maintenance cost
03) Lower noise level in ER
04) Simple and most compact installation

Varying speed of ME, driving a fixed pitch propeller, can be converted by variable gear ratio, to provide constant Generator speed.

SURVEY AND INSPECTION

How to Plan for Machinery Survey

- a Check survey list of machinery or instruction of company for survey
- a Check spares and tools for survey machinery
- a Man power and time available in port
- a Read instruction manual and previous record.
- a Brief other engineers for engaging work
- a After reaching port, take permission from port authority if required and start doing work with necessary precaution

UNIT SURVERY (MAN B & W Engine)

(A) Planning

01) Get exact date of survey and estimate immobilization period

02) Check and prepare all necessary spares and tools

03) Tools:

a) Piston and Cylinder Cover

- Hydraulic pump, hoses and cylinder head jacks
- Lifting gears e.g. engine room crane, shackles, slings etc.
- Piston lifting tool and cylinder head lifting tool
- Piston ring funnels or ring compressor
- Stuffing box spacer and hole cover
- Feeler gauge and internal micrometer.
- Piston ring expander
- Piston stand
- Piston crown template
- Liner calibration template
- Liner calibration ladder
- Other necessary tools

b) Liner

- Liner lifting tool and liner support beam
- Liner jack and jack support

04) Spares

- Piston rings
- Piston O-ring
- O-ring, rings and springs for stuffing box
- Liner O-ring
- Cylinder head joint
- Other connection clearance etc.

05) Consult manual for special instructions and data e.g. jacking pressure, clearance etc.

06) Check all lifting devices and crane for SWL, corrosion and other damage

07) Test lifting gears

08) Check hydraulic pump, jacks, HP hoses and connections for satisfactory operation

09) Prepare and check previous survey records

10) Carry out briefing for every one involved in the work about precautions, work to be done and time available

11) Safety gears to be worn during work

12) Prepare piston stand near engine

(B) Shutting Down and Removal of Connection

(01) On F.W.E, get immobilization permission and propeller clearance from bridge. Inform bridge of estimated immobilization period.

(02) After blow through, shut starting air valve on air bottle
(03) Engage turning gear and turn for at least ½ hour, crank CLO 40-50 times
(04) After ½ hour, stop LO pump and stop turning but keep the turning gear engaged
(05) Put up notices in the control room for the M/E pumps, which has been stopped and also on the engine control
(06) Open crankcase door and start ventilation by blowers.
(07) Open scavenge space door and under piston door and start ventilation
(08) Isolate JW inlet and outlet valves for the unit affected and start draining. JW pump kept running for keeping other units warm
(09) Isolate fuel inlet and return valves for the affected unit. Fuel is on re-circulation for other units
(10) Shut off the control air and safety air supply. Also shut off the air supply in the reduction unit for the hydraulic /pneumatic exhaust valve, and vent the system.
(11) Remove
- Exhaust bellow and sensor
- JW outlet pipe before the outlet valve, thermometer and temp sensor
- Spring air connection
- Actuator oil drain
- Hydraulic actuator HP Pipe
- Injector HP pipes
- Injector fuel return connection
- Staring air valve connection
- Staring air valve pilot connection

12) Protect all openings with clean rags

Removal of Cylinder Head

- Fit hydraulic jacks on all cylinder head nuts and connect the HP hoses
- Open jack vents and start to pump slowly ensuring no excessive pressure build on
- Use Tommy bar to loosen nut, ensure all nuts are loose
- Release pressure, remove jacks and remove nuts.
- Fit cylinder head lifting tool
- Lift slowly the cylinder head using the E/R crane
- Care must be taken when lifting so as cylinder head does not comes in contact any other engine part during lifting thus causing damage
- Place the cylinder head on a couple of wooden planks.
- Remove and discard the sealing ring between cylinder cover and cylinder liner.

Piston Removal

- Turn the crosshead down for enough to give access to the piston to rod stuffing box. the tightening screws for the piston rod, and to the telescopic pipe
- Release the stuffing box by removing the innermost screws for the stuffing box flange Turn piston towards TDC but stop much before it reaches TDC
- Remove the screws from the piston rod.
- Mount the two distance pieces on the piston rod foot to protect the lower scraper ring and to guide the stuffing box.
- Carefully smooth out any wear ridges at the top of the cylinder liner by using a hand grinder
- Put some grease on the circumferential gap between piston and liner
- Turn the crosshead to TDC, while checking that the guide pins of the distance pieces enter the holes in the stuffing box.
- Clean the lifting groove of the piston crown and mount the lifting tool
- Ensure crane is straight and ship is even keel
- Using E/R crane slowly lift up the piston

- Ensuring piston is not swinging causing piston palm coming in contact with liner surface
- Once out, lower piston on its stand and place a cover over the opening for the piston rod stuffing box in the bottom of the cylinder unit.
- Remove the lifting tool

Liner Removal

01) Remove all quill connections for that unit
02) Remove liner-securing bolts
03) Mount the two lifting screws in the cylinder liner
04) Remove the screws of the cooling water in let pipe
05) Attach the crane to the lifting tool. Hook the chains from the lifting crossbar on to the lifting screws and lift the cylinder liner with the cooling jacket out of the cylinder frame
06) Land the cylinder vertically on, for instance, a couple of planks.
07) Lift away the cooling jacket by means of the tackles and land it on the wooden planks
08) Check and assess the condition of the cylinder liner.
09) Clean the cylinder liner and the cooling jacket both internally and externally. Pay special attention to the O-ring grooves and lubricating ducts.

Inspection and Cleaning

- Before commence cleaning assess piston crown, ring grooves and oil grooves
- After cleaning, check crown burn out using the template and measure the burn out
- Assess for signs of wear, crack, scoring and pitting
- Also check ring groove condition
- After cleaning of liner and fitting back, it is checked for wear, scoring etc
- Calibration taken
- Checking of ring clearance and piston clearance
- CLO flow checked
- Piston crown and skirt opened up for survey, cleaning
- Assemble and pressure test

UNIT SURVERY (Sulzer RTA Engine)

(A) Planning

01) Get exact date of survey and estimate immobilization period
02) Check and prepare all necessary spares and tools
03) Tools:

a) Piston and Cylinder Head
- Hydraulic pump, hoses and cylinder head jacks
- Lifting gears e.g. engine room crane, shackles, slings etc.
- Piston lifting tool and cylinder head lifting tool
- Piston ring funnels or ring compressor
- Stuffing box spacer and hole cover
- Feeler gauge and internal micrometer.
- Piston ring expander
- Piston stand
- Piston crown template
- Liner calibration template
- Liner calibration ladder
- Other necessary tools

b) Liner
- Liner lifting tool and liner support beam
- Liner jack and jack support

04) Spares
- Piston rings
- Liner O-ring
- Piston O-ring
- Cylinder head joint
- O-ring, rings and springs for stuffing box
- Other connection clearance etc.

05) Consult manual for special instructions and data e.g. jacking pressure, clearance etc.
06) Check all lifting devices and crane for SWL, corrosion and other damage
07) Test lifting gears
08) Check hydraulic pump, jacks, HP hoses and connections for satisfactory operation
09) Prepare and check previous survey records
10) Carry out briefing for every one involved in the work about precautions, work to be done and time available
11) Safety gears to be worn during work
12) Prepare piston stand near engine

(B) Shutting Down and Removal of Connection

(01) On F.W.E, get immobilization permission and propeller clearance from bridge. Inform bridge of estimated immobilization period.
(02) After blow through, shut starting air valve on air bottle
(03) Engage turning gear and turn for at least ½ hour, crank CLO 40-50 times
(04) After ½ hour, stop LO pump and stop turning but keep the turning gear engaged
(05) Put up notices in the control room for the M/E pumps, which has been stopped and also on the engine control
(06) Open crankcase door and start ventilation by blowers.
(07) Open scavenge space door and under piston door and start ventilation
(08) Isolate JW inlet and outlet valves for the unit affected and start draining. JW pump kept running for keeping other units warm
(09) Isolate fuel inlet and return valves for the affected unit. Fuel is on re-circulation for other units
(10) Spring air valve isolated
(11) Remove
- Exhaust bellow and sensor
- JW outlet pipe before the outlet valve, thermometer and temp sensor
- Spring air connection
- Actuator oil drain
- Hydraulic actuator HP Pipe
- Injector HP pipes
- Injector fuel return connection
- Staring air valve connection
- Staring air valve pilot connection

(12) Protect all openings with clean rags

Removal of Cylinder Head
- Fit hydraulic jacks on all cylinder head nuts and connect the HP hoses
- Open jack vents and start to pump slowly ensuring no excessive pressure build on
- Use Tommy bar to loosen nut, ensure all nuts are loose
- Release pressure, remove jacks and remove nuts.
- Fit cylinder head lifting tool
- Lift slowly the cylinder head using the E/R crane

- Care must be taken when lifting so as cylinder head does not comes in contact any other engine part during lifting thus causing damage
- Place the cylinder head on wooden blocks

Piston Removal

- Turn piston to BDC and remove piston palm bolts and locking device
- Fit the stuffing box spacer on the piston palm
- Remove stuffing box securing bolts and its locking device
- Turn piston towards TDC but stop much before it reaches TDC
- Remove cylinder head metal gasket
- Put some grease on the circumferential gap between piston and liner
- Clean liner surface of deposits so, as piston does not get stuck during extraction
- Clean and re-tap the lifting holes on the crown
- Fit piston lifting tool ensuring all bolts are secured
- Ensure the liner securing bolts are still in position and secured
- Ensure crane is straight and ship is even keel
- Using E/R crane slowly lift up the piston ensuring the stuffing box spacer does not contact with the diaphragm
- Continue to lift ensuring piston is not swinging causing piston palm coming in contact with liner surface
- Once out, lower piston on its stand and secure the stuffing box
- Remove the lifting tool

Liner Removal

01) Remove all quill connections for that unit
02) Remove liner-securing bolts
03) Lower the liner support beam vertically and rest it on the diaphragm
04) Change sling position and swing it around and lift it up a little so that it can be fitted to the under side of line
05) Once beam properly secured, sling and crane hook is removed from inside of liner
06) Turn engine till TDC
07) Fit the jack support on to the cross head pin
08) Put the jack on top of the support and connect it with hydraulic pump using HP hoses
09) Purge air from jack using the vent and pump slightly
10) Once air is purged, start jacking slowly
11) Slight pressure should be able to push the liner
12) If too much pressure, stop pump release pressure and re-check the connection
13) Once liner is shifted out of the guide, fit the liner lifting tool on the liner flange
14) Attach crane and lift up liner slowly
15) Lay down the liner carefully and secure it
16) After securing, remove liner support beam
17) Release jack pressure, remove jack and jack support
18) Cover the stuffing box hole using the cover provided

Inspection and Cleaning

- Before commence cleaning assess piston crown, ring grooves and oil grooves
- After cleaning, check crown burn out using the template and measure the burn out
- Assess for signs of wear, crack, scoring and pitting
- Also check ring groove condition
- After cleaning of liner and fitting back, it is checked for wear, scoring etc
- Calibration taken
- Checking of ring clearance and piston clearance

- CLO flow checked
- Piston crown and skirt opened up for survey, cleaning
- Assemble and pressure test

Cylinder head survey

01) Take immobilization from port authority
02) Close main air stop valve and lock starting system.
03) Engage turning gear and stop L.O pump.
04) Close jacket water valves (in/out & necessary valves)
05) Drain jacket water to a certain level to prevent flow out.
06) Remove off all pipe connection on cylinder head
07) Remove all valves on cylinder head
08) Clean thread from all cylinder head studs.
09) Loosen the cylinder head nuts by hydraulic tensioning device and remove them.
10) Attach lifting eye bolt (special tool) on the cylinder head.
11) Lift the cylinder head by crane with suspension rope.
12) Place the cylinder head on stand
13) Clean all of the valves pockets and check crack.
14) Open water chamber inspection door and clean
15) Clean under side of the cylinder head and check wear, flame impingement, distortion, and crack.
16) Display surveyor.

Cylinder liner survey

(1) to (7) from cylinder head survey.
08) Remove the cylinder head *and press liner by using liner pressing tool.*
09) Turn crank shaft until the piston is BDC.
10) Clean liner wall, exhaust and scavenge posts thoroughly.
11) Take measurements on liner by using micrometer, extension bar and template.

11a) Max wear ⇨ 0.75 ~ 1.0 of original
11b) Wear rate ⇨ o.1 mm/1,000 hr

12) Check cylinder lubrication by operating
13) Display liner and measurements to surveyor.

Piston survey **(M/E unit survey procedure)**

(1) to (7) from cylinder head survey
8,9, 10 from cylinder liner survey

11) Remove 1 Stuffing box holding nuts from diaphragm
2 Piston cooling connection
3 Piston rod nuts.

12) Turn the crank shaft until piston is TDC.
13) Remove combustion deposited from the thread hole of the piston crown by using thread tab.
14) Screw down piston lifting tool at the thread hole of the piston crown and connect it to crane.
15) Pull up the piston by crane out of the liner together with stuffing box.
16) Place piston on the top platform.
17) Remove piston rings and clean piston and ring grooves
18) Overhaul the stuffing box.
19) Clean the liner and check times lubrication
20) After cleaning work complete measurement to be taken on the following place. Then display the parts for surveyor.
a) Piston crown wear (max wear allowance shown on special template)

b) Piston ring gap clearance (Max allowance is 3 times of the original)
c) Piston ring vertical clearance
d) (0.2 to 0.25 mm)
e) Radial thickness of piston rings. (Generally (1/13)one thirteenth of the cylinder bore diameter)
f) Cylinder liner bore (Calibration) (Max wear 0.75 to 1.0% of original)
g) Stuffing box sealing and scraper rings, gap and groove clearance. (Gap clearance = 6 mm for each gap)Total gap clearance = 18 mm for 3 segments (groove clearance = 0.07 to 0.12 mm)

Cross head Bearing survey

01) Take immobilization from port authority
02) Close main air stop valve and lack staring system.
03) Engage turning gear and stop L.O pump
04) Open crankcase doors / Stop M/E warming.
05) Turn crankshaft until crank is horizontal position.
06) Take guide shoe clearance and side clearance by using feeler gauge.
07) Turn crank shaft until crank is BDC.
08) Take bearing clearance by inserting feeler gauge between bearing upper half and X head pin.
09) Remove bearing cap nuts of both sides.
10) Fit eye bolts on the bearing upper half and remove them outside from the crankcase.
11) Turn crankshaft until crank is TDC.
12) Tie the connecting rod with two chain block.
13) Fit the hanging bar in position according to the operations manual.
14) Turn the crankshaft until the bearing lower half clear from X head pin.
15) Take measurements of X head pin at least 3 place top, bottom and port, stb. check ovality.
16) Display surveyor, check points are –
- **a)** Bearing clearance (for X head bearing = 0.2 – 0.5 mm)
- **b)** Shoe and guide clearance (for surface 0.25 – 0.55 mm)
- **c)** Shoe and guide clearance (for each side = 0.1 – 0.2 mm)
- **d)** Bearing surface (No crack and No damage)
- **e)** Oil holes and grooves (no damages)
- **f)** X head pin ovality
- **g)** X head pin surface (No crack and No damage)
- **h)** Lubricating system (clear)

Big end bearing removing and fitting procedure.

1) *Take immobilization from port authority*
2) *Close main air stop valve and lock starting system*
3) *Engage turning gear and stop L.O pump*
4) *Open crankcase door*
5) *Turn crankshaft until the crank is BDC*
6) *Measure bearing clearance by inserting feeler gauge between bearing lower half and crankpin.*
7) Turn the crank shaft to TDC position.
8) Remove locking arrangement and slackened the nuts. The bottom half lower a few and took out bearing clearance adjusting shim, each set being tied separately and note taken of the side to which each set belongs.
9) Chain blocks connected to eye bolts, screw into each bolt. After removing two nuts, bottom half lowered into the sump. Putting hanging bar in position, connect chain blocks to crankcase door frame and eye bolts which is screwed into each side of the top half. Then turn the crankshaft to the position where the top half can be taken out.
10) Also take out the bottom half with bolts outside the crankcase

11) Inspection on crank pin, bearings, oil holes, grooves, bolts cracks, sign of movement and elongation.

11) Take measurements of crank pin at least 3 place top, bottom and port, stb check ovality.

12) Display surveyor, check points are

12a) Bearing clearance (0.5 to 0.7 mm for 550 mm diameter crank pin)

12b) Bearing surface (No crack, no damage and if wipe out 30% renew it)

12c) Check holding down bearing surface.

12d) Oil hole and grooves (No damage)

12e) Crankpin ovality and its surface

12f) Lubricating system (clear)

12g) Big end bearing bolts (Good thread, no extension, no cracking and no twisting)

12h) heck sign of movement of the joint point such as two halve of bearing joint and between top halve and connecting rod foot.

Main bearing survey **(Sulzer, RL)**

01) Take immobilization from port authority
02) Close main air stop valve and lock starting system.
03) Engage turning gear and stop L.O pump
04) Open crankcase door.
05) Turn crankshaft until crankshaft is convenient position
06) Take bearing clearance by inserting feeler gauge between bearing upper half and journal
07) Remove the L.O supply pipe and locking arrangement.
08) Remove the bearing keep nuts or bolts.
09) Fit eye bolt on the upper bearing dip and remove it outside from the crankcase
10) Also fit eye bolt on the upper bearing shall and remove it outside from the crankcase.
11) Use special spanning, bolted to the adjacent crank web of the concerned bearing, the end of which are engaged to the collar of the lower bearing shall.
12) Turn the crank shaft about half revolution to the opposite of the running direction.
13) Bearing half will rotate with the shaft to the top opposition.
14) Fit eye bolt to the back of the shell and lift it out of the engine.

Some methods use hydraulic jacks to lift the crankshaft a few distance, about 0.1 to 0.3 mm, and turn the bearing shell without rotating the crankshaft.

15) Measure throughout the journal at least three places (top, bottom and port, stb) to check the ovality.
16) Display surveyor, check points are,
- **a)** Bearing clearance (*0.4 to 0.6 mm for 500 mm diameter journal*)
- **b)** Bearing surface (No crack and No damage)
- **c)** Oil holes and grooves (No damage)
- **d)** Bearing tap (No damage)
- **e)** Journal ovality (25% of max: oil clearance)
- **f)** Journal surface (No crack and No damage)
- **g)** Lubricating system (Clear)

Main engine unit survey procedure.

(01) Works should not be disturbed the ship's sailing schedule.
(02) Immobilization must be taken from the port authorities.
(03) Group the engine room engine room staff, each group having an engineer and assisting crew for efficient work.
(04) Prepare tools and spare parts to be used.
(05) Engage turning gear. Stop lub oil pump, piston cooling, fuel valve cooling and close jacket cooling water inlet and outlet valves.
(06) Piston to be put to TDC by turning gear.

(07) Exhaust valve and pipe, fuel pipes, fuel valves, fuel valve cooling pipes and air starting pipes to be removed.
(08) Removed cylinder head nuts and cylinder head by engine room crane, placed it on special stand or wooden bocks.
(09) Remove piston rod nut, attach piston lifting attachment to piston crown after cleaning thoroughly the bolt holes by using taps. Pressing up liner with maker supply tool. The piston with the rod to be taken out by means of engine room crane. Care should be taken to prevent the piston rod thrust on the stuffing box and liner wall. The piston assembly to be placed on the top platform.
(10) If the stuffing box required to be overhauled, it can be taken out together with piston or separately.
(11) Clean all carbon deposits on the piston crown, rings, ring grooves, liner with exhaust and air inlet ports and scavenging space.
(12) Inspect piston rings broken or sticking in grooves, liner and piston crown burning and wearing. Pressure test to piston cooling system. Tested cylinder lubricators.

Took measurements
1) Cylinder liner bore. (max: wear 0.75 to 1% of original)
2) Piston crown wear. (wear down gauge)
3) Piston ring gap clearance. (max: 3 times of original)
4) Piston ring vertical clearance. (0.2 to 0.25 mm)
5) Radial thickness of piston ring. (One thirtieth of cylinder bore diameter)
6) Stuffing box sealing and scraper rings gap clearance. (6 mm at each gap)

Dry Docking Preparation

(a) A few months before

1) Information about The dry docking (estimated time and duration) to be taken from C/E
2) Preliminary repair list must be collected and arranged by instruction of C/E.
3) Repair work to be divided into two categories; one for dockyard and other for the ship's staff. The repair list must contain the followings
  a. Nos. of sea suction chests and grids and their size
  b. Nos. of sea suction valve and their sizes.
  c. Nos. of ship side discharge valve and their size.
  d. Nos. of scupper valve and their sizes.
  e. Nos. of piping to be repaired including their length, inside/out side diameter, bends, no. of flange and their P.C.D [including detail drawing]
  f. No. of engine room valves to be renewed or repaired and their specifications.
  g. Main engine overhauling preparation (1) Spare (2) tools (3) measurement (4) instruction manuals.
  h. Auxiliary engine, boiler, pump & other machinery preparation for overhauling.
4) Exact location of items to be repaired or overhaul must be marked with tag label according to repair code.
5) Tools and spares, stores should be checked and prepared for use.
6) Store and spare requisition which will be repaired to use during docking periods must be ordered.
7) All tools must be marked with paints to prevent mixing with shipyard's one.
8) Organization of E/R staff ie. Safety purpose, assign works.
9) Distribute work assignments among engine room staff in group by group.
10) Maker's instruction on manuals and all drawing must be kept ready for prompt work.

(2) A few days before

1) Ballasting and transferring carried out in corporation with chief officer to achieve required trim and draught.
2) Engine room bilge well and tank top to be cleaned thoroughly.

3) All tank sounding to be taken and account.
4) All portable fire extinguishers to be ready at required place.
5) Fire fighting fixed installation to be kept ready at required by shipyard's rule.
6) Emergency generator, emergency fire pump, emergency air bottle, emergency air compressor must be kept in good condition.
7) Shore cooling sea water supply for refrigeration and air condition plant must be ready to receive.
8) Shore electrical supply (at entry of dock) Phase, Hz, V, AC or DC.
9) Main engine crank shaft deflection to be taken and recorded.

(3) Before a few hour

1) Boiler should be shut down and release all steam pressure by using easing gear.
2) An instruction to give all engine room personnel that smoking is prohibited in engine room at ship is still in dock.
3) Main air bottle, emergency air bottle pressed up to full and close tightly.
4) Ready to stop ship generator as soon as vessel enter dry dock and to be kept an electrical officer stand by on shore connection box when shore power is taken.
5) Settling and service tank top up, after topping up sounding of all tanks must be taken and recorded.
6) Remind all engine room personnel their duty and ready for emergency use.

(4) On dock

1) Repair work to be divided into two categories, one for ship staff and other for dry dock.
2) Tool and spare must be checked and prepared for use.
3) Take daily record of work done by ship staff and dry dock workers.
4) Negotiate with in charge of dock yard about work sequence and show him location of item to be repaired.
5) At the end of every day, feed back condition of work to C/E.
6) Examine all work done by dry dock and engine crew. If unsatisfactory condition was found, inform to C/E and dock yard in charge.
7) All engine room personal should be instructed to use store and spare thoroughly and without wasting.
8) Bottom survey carried out together with class surveyor, master & C/O.
9) Assist class surveyor visit and his subsequent survey.
- ★ Supervise when at sea cannot overhaul works.
- ★ At witness for docking survey item.
- ★ Supervise the docking repair item.
- ★ Measure stern tube wear down, rudder wear down and jumping clearance.
- ★ Propeller check cavitation, corrosion and any damage (Crack, deformation)

After Dry Docking

- ☞ Price Negotiate (Man/power, material /repair list)
- ☞ Dock charge damage claim
- ☞ Report
- ☞ Closely check sea valves
- ☞ Performance of repaired machinery
- ☞ Took M/E crankshaft deflection.

Crankcase Inspection

01. Consult with Chief Engineer and inform Master
02. **Safety**

- Shut off main air starting valve and air bottle main valve
- Open indicator cocks and engage turning gear
- Ensure engine has been turned for at least half an hour before stopping lub oil pump & cross head oil pump
- Stop lub oil pumps & cross head oil pump and circuit breaker off. Post notice **"Don't Start Men at Work"**
- Inform duty officer for propeller clearance.
- Open crankcases door and ventilate properly.
- Wear safety gears e.g. helmet, boots, raincoat , gloves etc.
- Use safety lamps, torches and tools
- Pockets to be emptied of contents and tools taken inside to be accounted for.
- One responsible person must be standing outside.

03. Inspection

- Firstly check oil condition for any smell, discoloration or degradation.
- Turn engine to BDC and start checking from under stuffing box area for any signs of black oil, if so indication of stuffing box leaking.
- Check piston rod surface for scoring marks and roughness.
- Check piston palm bolts and locking device for slackness and fretting.
- Check guide and guide shoe bearing general condition and area around frame where guide is attached for any visible cracks.
- Check guide shoe end cover bolts in place and not slack.
- Check cross head bearing general condition
- Top & Bottom end of con-rod bolt, nut and locking device for slackness, sign of fretting etc.
- Check sliding of bottom end bearing (axial movement) or floating of con –rod.
- Check for slip of web and journal by checking the reference mark
- Check web in the area of stress concentration and check tie bolts (bottom side)
- Check cross girder, area around main bearing and bearing keep for signs of cracks and check main bearing.
- All bearings to be checked for **silvery colour** (indicates bearing wiping)
- Check all surrounding of oil pan area of all units for any sludge deposits, bearing metal pieces etc.
- Check crank case relief door ⇨ wire mesh (should be wet) spring tension, sealing ring condition etc.
- Check the teeth of transmission gears for signs of wear
- Check chain drive for tightness.
- Oil mist detector sampling pipe to be checked for clear passage.
- Clear foreign materials from the crankcase and tools accounted for.
- Start lub oil pump and cross head oil pump and check oil flow and distribution
- Check crank case door sealing condition and close crank case door.
- Inform Chief Engineer (for satisfactory checking of C/C) and Duty Officer.

CHAIN CASING INSPECTION.

Before 4,000 running hrs and after lengthy voyage, chain tension is checked at mid span of slack side, in transverse direction.

Limited transverse movements is ½ to one link pitch on slack side.

Excessive tension may cause chain breakage.

Excessive slackness may cause vibration and eventual failure.

Elongation (chain wear) is checked between 3,000 - 5,000 running hours

Total length of 10 links drawn tight and measured and chain stretch calculated in % by comparing with original length of 10 links.

Maximum elongation : not exceed 2% . Over 2% the whole chain must be renewed.

Due attention to be given when the elongation reaches 1.5 %.

Stretching is the results of pin and bushing surface wearing out.
Chain length is measured in terms of number of links.

01) Stretching of the chain must be measured periodically.
02) Check wear of the chains, teeth of sprockets, bearing of wheels.
03) Check any seized up of rollers.
04) Check for fatigue cracks on rollers & link plate.
05) Check alignment of the wheels by examining every links for blemish, and for bright marks on side plate. (due to misalignment of wheels)
06) Check abnormal wear takes narrow polished strips on the inside surface of the sprockets teeth.
07) Check for loose bolts & pipe connection.
08) Check lub: oil pipes, sprayers, oil flow & direction.
09) Check rubber clad guide ways for cracks.
10) Slackness

Excessive Tension - will cause high loads, possible damage and breakage of the chain system.

Symptom of slack chain.

01) Excessive chain vibration and noise due to slackness.
02) Loss of power in all units indicated by power card.
03) Late injection and low Pmax revealing on out of phase card.
04) Late closing of exhaust valve in all units can be seen on light spring diagram with high exhaust temp: & smoke.

Effect of slack chain.

1) Slack chain will impose ***heavy mechanical load*** and adding to cyclic stresses which could result ***fatigue failure.***
2) Slack chain damages both *chain system* and *engine frame*.
3) Slack chain cause retardation of timings of fuel pumps and exhaust valve resulting:
- ☛ Reduce scavenging efficiency, *due to late closing of Exhaust valve*
- ☛ Reduce engine power,
- ☛ Low Pmax, *due to late injection*
- ☛ High exhaust temp: with smoke, *due to after burning*

4) Can cause hot spot.

Chain slackness checking.

1) Turning (*astern*) the engine so that slack part of the chain is on the side of tension wheel.
2) Pull vigorously to and fro at the middle of the free length of the chain. Under normal condition the chain should vibrate by half to one chain link.
3) If the chain is slack it should be adjusted.
4) Measure @ the longest span.
5) By measuring the transverse displacement of the chain at its mid point between two designated sprockets.

Allowance 1/2 to 1 link, more than 1 link - readjusted.

Elongation allowance.

Elongation more than 2% of original length - renew.
Elongation more than 1.5% of original length - closely care.

How to check chain elongation

🛠 Turn the engine to ahead direction, so as to set the tightness of chain.

- Measure the length of the chain between two fix points and count the nos. of chin link pitch. Then original chain length can be calculated from instruction book.
- Calculate original chain length = Nos. of chain link pitch x Original pitch length
- Then compare with the original chain length and actual chain length.

$$\text{Calculate elongation} = \frac{\text{Measure actual chain length} - \text{Maker siven original chain length}}{\text{Original chain length}} \times 100$$

- Maximum elongation on the chain should not exceed 2% and due to attention to be given when elongation reaches 1.5 %.

RESPONSIBILITY OF 2ND ENGINEER

Duty and responsibility of 2nd Engineer is to plan, operate and carry out work in accordance with established rules and procedures to Safe Guard Life at Sea, Protect Marine Environment and Maintain the Seaworthiness of the vessel at all times.

Maintain and Update Documentation

Documentation under 2nd Engineer responsibility which requires maintaining and updating are as follows-

- Daily record book.
- Machinery maintenance record book
- Defect and repair list
- Major spares inventory
- Oil record book
- Saturday routine book
- Engine room logbook
- Updating of PMS
- Stores and ROB (spares of Aux. Machinery)
- Lub oil and chemical inventory
- FFA and LSA record book (LSA – BA, Life jacket, ELSA etc)

Engine Room Management

- Personally responsible to CE
- Ensure engine room is properly manned
- Proper distribution of job
- Clear briefing done before a job is carried out.
- Ensure all engineer and crew practice safe working procedure and wears safety gears at all times.
- Guidance and proper training of juniors
- Ensure everyone understands the consequence of pollution
- Responsible for compilation of all work done for future records

Engine Room House keeping

- Ensure E / R is maintained in a clean, painted and sanitary condition
- Ensure all tools and stores are kept safely and location recorded.
- Secure all heavy items at all times
- All leaks and damages are attended as soon as possible
- Bilge garbage and sewage management as per regulation

Safety of Engine Room and Ship

- Ensure all engineers know the location of LSA and FFA.
- All emergency escape routes are clearly marked and clear of any obstruction
- Malignance of all FFA and LSA under 2nd engineer's responsibility

Carry out Saturday routine

- Testing of emergency fire pump
- Emergency generator and emergency air bottle.
- Lifeboat engine
- Fans and ventilation
- CO_2 bottles (links, secured location of key)
- Testing of fire detectors.
- Testing of engine room fire extinguishers.
- Checking of funnel flaps.
- Hydrant and nozzles in engine room
- Ensure operated fire doors.
- Safety harness and fireman's outfit in engine room
- Engine room ship side valves operated
- Testing of engine room lifting gears

Machinery Maintenance

- In state of readiness at all times
- Proper round checks carried out
- Safe operation of all machinery on board
- PMS jobs to be carried out
- Attend to all major repair work
- Keep track of all defects and repair required
- Able to manage any other emergency repairs outside PMS
- Ensure handing / taking over reports cover the engineer's general duties, their performance and any special job as a requirement.

Pollution Prevention

- Ensure all Engineers know –
- Procedure of oily water separator
- Procedure of incinerator
- Procedure of sewage plant
- Oil record book and E / R logbook updating
- Bunkering / transferring procedure
- Bilge overboard valves are shut and locked in port and in special areas.

Emergency Procedures

- Steering gear emergency procedure
- Main Engine local control
- Fire and abandon ship drill
- Flooding / Grounding / Collision
- Power failure procedures
- Oil spill drill

TAKING OVER AS 2ND ENGINEER

- Report to Chief Engineer and Master
- Meet to out going 2nd Engineer and go through-
  - **a)** 2nd Engineer's work done book
  - **b)** Oil record book
  - **c)** Machinery maintenance book
  - **d)** Spares inventory record book
  - **e)** ROB of fuel oil, Lub oil and Chemicals record
  - **f)** LSA and FFA maintenance book
  - **g)** Saturday routine book

h) Engine room defect list
i) Spare requisition (record of emergency spares)
j) Finished plans and operating manuals
k) Engine room logbook

- ⇆ Go through the handing over report with out going 2/E and ask if any doubt
- ⇆ Special standing instruction by chief engineer
- ⇆ PMA outstanding maintenance
- ⇆ Take rounds of engine room – familiarize
- ⇆ Know all emergency exits
- ⇆ Know your emergency station
- ⇆ Check all FFA and LSA in E/R, also the fire detectors
- ⇆ Know the special tools location
- ⇆ Visual inspection of M /E, Boiler, D /G, OWS and incinerator
- ⇆ Visual inspection of steering flat and steering gear condition
- ⇆ Visual inspection of tank top and pipe lines condition
- ⇆ Visual inspection of motors, lighting and electrical appliances
- ⇆ Check bilge pumps and ships side valves
- ⇆ Emergency steering procedure
- ⇆ Local manoeuvring procedure of M /E
- ⇆ Check emergency fire pump, emergency generator and emergency compressor
- ⇆ Lifeboats condition (internal & external) and test the lifeboat engine
- ⇆ Check boiler area and if it is not being used for cargo discharge then a few safety cut outs to be tested and check gauge glass.
- ⇆ Inspect the fix fire fighting system and know the checks to be made and check past records
- ⇆ Know the bunker lines and valves
- ⇆ Fuel and LO tanks location and quantity
- ⇆ Check a few UMS alarms
- ⇆ Get to know sub-ordinates and their responsibilities
- ⇆ Know the performance of the ship staff from outgoing 2E

MAIN ENGINE SAFETY DEVICES

SAFETY DEVICES	**SAFETY TRIPS** (Safety Devices)	**ME SLOW DOWN**
1. Crankcase relief door	1. Over speed trip	1. LO high temperature
2. Scavenge space relief valve	2. Lo low pressure trip	2. JCW high temperature
3. Cylinder head relief valve	3. Camshaft LO low pressure trip	3. Piston cooling high temp.
4. Staring air relief valve	4. Piston cooling low pressure trip	4. OMD alarm
5. Starting airline flame trap	5. JCW low pressure trip	5. Thrust bearing LO low press
6. Oil Mist Detector	6. Thrust bearing high temp. trip	6. Control air low pressure
7. Rotation direction interlock	7. Main bearing high temp. trip(may be)	7. Scavenge air high temp
8. Turning gear interlock	8. OMD alarm (in case of excess oil most)	8. Exhaust gas high temp
	9. Spring air low-pressure trip	
	10. Manual emergency trip	

SHAFT GROUNDING SYSTEM

- ★ Spark Erosion: Caused by voltage discharge between the main bearing & journal
- ★ The cause of the potential is the development of a galvanic element between the ship's hull (by seawater), and propeller shaft / crankshaft
- ★ The voltage produced should be grounded; spark erosion occurs if not grounded

- ★ The oil film acts as a dielectric. The puncture voltage in the bearing depends on the thickness of the oil film
- ★ If load increases oil film thickness decreases.
- ★ In early stage, the roughened area can reasonable pitting erosion, but later will roughness increases; the small craters will scrape off and pick up the white metal, hence the silvery white appearance.
- ★ Keep shaft voltage below 50 mV.
- ★ High voltage means shaft is not grounded properly
- ★ Spark erosion occurs between main bearing and journal only.

What do you do at heavy sea as a 2/E ?

- Fill settling & service tank and drain water and impurities sediment
- Fill sump oil of all machines if necessary
- Clean F.O strainer and place then stand by
- Secure all parts which can be move in rough sea
- Run stand by generator and place it parallel
- Reduce Main engine speed if necessary
- Instruct all watch keeper to call 2/E if necessary
- Instruct on watch keeping engineer to stay in E/R and one watch keeper to check all engine room running machines and other possible damage.

.Shipboard Oil Pollution Emergency Plan: SOPEP

Every oil tanker of 150 GRT and above, and every ship of 400 GRT and above, shall carry onboard a Shipboard Oil Pollution Emergency Plan.

The plan shall consist at least of:

1) **Procedures** to be followed by Master, or other person having charged of the ship to report an oil pollution incident.
2) **List of authorities or persons to be contacted**, in the event of oil pollution incident
3) **Detailed description of actions** to be taken immediately by persons onboard, to reduce or control the discharge of oil
4) **Procedures and point of contact onboard**, for coordinating shipboard action with local authorities in combating pollution.

Procedures, when accidental oil overflow occurs:

1) Notify Harbour /Terminal Authority immediately through the Master
2) Actions immediately taken by persons onboard to stop, reduce or control the oil discharge
3) Coordinate shipboard actions with local Authorities
4) Inform owner, agent, P & I Club, Flag State Authorities, and vessels in vicinity
5) Invite P&I (Protection and indemnity) correspondents
6) Record in ORB, time & place of occurrence approximate amount & type of oil, circumstances of discharge or escape.

Before arrival procedure

01. When one hour notice is given from bridge
02. Inform to C/E
03. Call the required engineer assistance
04. Stop F.W.G
05. To change H.O to D.O shut F.O heater steam valve
06. Slowly reduce engine speed from sea speed to harbour speed
07. Change the lubricator position and adjust air cooler temperature, put auxiliary blower (auto)
08. Start the stand by generator & sharing load
09. Start the oil fire boiler
10. Pressure up main air bottle and drain out oil & water

11. Check bilge O/B valve closed. Lock position and sewage valve
12. Change fuel system H.O to D.O when temperature reach 90°C
13. Record flow meter counter & time changing time
14. When S/B telegraph is received, take S/B M/E revolution counter.

Before departure to sea

Before departure the port, all machineries must be kept in good working order and keep ready to sea.

24 hours prior vessel's departure

Upon receipt of departure notice, the following is to be carried out, 24 hours ahead of the event.

01) Maintain a sufficient level of fuel in the diesel/heavy oil service tanks. Transfer oil to fill up settling tanks (H.O and D.O) prior to arrival in port. No oil transfer to be carried out in port, as far as possible.
02) Drain off water from Fuel tanks, while maintaining the tank temperatures.
03) Ensure filters in L.O and F.O pipelines are clean
04) Check operation of safety equipment including emergency generator and safety devices on the starting air system must be in good order.
05) The starting air valves also should be tested for leakage.
06) Check temperature of jacket cooling water and adjust preheating, well in advance, in order to have the engine sufficiently warmed up. The cooling water temperature is to be about 60°C. The pipe system and cylinder jackets should be **examined** for leaks.
07) In cold climates, when necessary heated to main engine system oil.
08) Take soundings of al oil tanks and engine room cofferdams.
09) Start the exhaust gas boiler water circulating pump well in advance.
10) Within 12 hours before departure, check the operation of the steering gear, including the emergency steering.
11) Fill up both Air bottles to full pressure and drain off the condensate from the bottles
12) Records of the above must be maintained in the log book.

Two Hours before vessel's departure

On receipt of Notice

01) Start the second Generator check for normal operation and parallel onto the bus bars
02) Start the following Main engine auxiliaries
- **a.** M/E jacket cooling water pump
- **b.** M/E Piston cooling water pump
- **c.** M/E LO pump
- **d.** M/E FO booster pump
- **e.** Any other pumps associated with running of the Main engine.
- **f.** Ensure that the stand-by pumps are working, and all relevant valves are open while switching on various pumps mentioned above, ensure that the operations are smooth and trouble free and that pressures are normal.

03) Stop preheating, carried out for J.C.W & P.C.W, prior to the start of Min engine.
04) Verify that following are adequate for safe operation
- **a.** Main L.O sump tank
- **b.** Main and auxiliary engine cooling water expansion tanks
- **c.** Turbocharger L.O levels
- **d.** Fuel valve nozzle cooling tank
- **e.** Stern tube L.O overhead and gravity tank
- **f.** F.O/D.O service tank
- **g.** Boiler Hot well tank

05) Ensure that L.O Filters are clear and that the differentia pressure drop is normal.
06) After getting propeller clearance, the main engine is to be turn on by turning gear for a few minutes (three revolutions) and at the same time, the cylinder lubricators off all units are to be manually operated.
07) Disengage and secure turning gear, and drain the air bottles and the starting air line of water.
08) Blow through engine and shut all indicator cocks. Close drains on coolers, scavenge spaces, exhaust manifold and the economizer.

09) Try out the Main engine in ahead/astern direction; Verify that all alarms, safety devices and recorders are functional.
10) Test steering gear. Ascertain smooth operation and check for any leaks.
11) Airs whistle and telegraph to be tried out.
12) Check operations of windlass and mooring winches.
13) Departure checklist to be filled in plant ready for to staring.

Procedure after departure & full away

During start check the following

- ⇨ All exhaust valves are operating correctly
- ⇨ Turbocharger(s) are running
- ⇨ All cylinders are firing
- ⇨ All temperatures and pressures are normal and corresponding to the actual engine speed
- ⇨ Check for any leakage or unusual noise
- ⇨ All cylinder lubricators are working satisfactorily
- ⇨ When full away is ring on telegraph
- ⇨ F.O is heated and then the temperature of F.O is high enough for injection, M/E is change with D.O to heavy oil.
- ⇨ Note the flow meter counter reading
- ⇨ Close valve of main air bottle and open the vents of air staring line.
- ⇨ After engine is navigation speed, check again all temperature and pressure are within their permissible limit. Checks scavenge drain, stuffing box drain.
- ⇨ F.W.G can be start if the ship is not in 50 N miles form land.

Warming up of M/E necessary before sailing

Warming up of M/E is essential before staring because

1) Cold staring is very difficult
2) To prevent thermal stresses on working parts.
3) Circulating of jacket water effect is warming up of combustion chamber

If it is not warming up, the heat produced by compression of air at piston stroke will not enough to ignite the injected fuel

Thermal stress will occurs due to high temperature difference between cylinder liner and cylinder J.C.W

So, Main engine must be kept warming above 50 °C by G/E jacket cooling water or heater of Steam/Electric

Clean ballast tanks (C.B.T)

As a temporary measure, older tankers have been permitted to dedicate certain tanks to be used for ballast only. Cargo piping may be used for the introduction and discharge of the ballast.

Segregated ballast tanks (S.B.T)

New large tankers are required to be build with and adequate number of ballast (only) tanks, so that under normal circumstances water will not have to be carried in cargo tanks. Ballast is handled by means of other than the cargo discharge pipe system.

Checking after ship grounded.

- 👁 Open high sea suction & close low sea suction.
- 👁 Took all tank sounding every 10 minutes.
- 👁 Clean filters & sea strainer of sea suction.
- 👁 Took M.E crank shaft deflection & crank case inspection. (After ship grounded is free)
- 👁 Check propeller blade if possible.
- 👁 Carried out steering gear test.
- 👁 Check load & ampere when M.E turning by turning gear.
- 👁 Check Tunnel & intermediate bearing for hull deformation.

SOLAS CERTIFICATE

1. Passenger ship safety certificate.
2. Cargo ship safety construction certificate.
3. Cargo ship safety equipment certificate.
4. Cargo ship safety radio certificate.
5. Exemption certificate.
6. Nuclear passenger ship safety certificate.
7. Nuclear cargo ship safety certificate.

CERTIFICATE ON BOARD (CARGO SHIP)

1. Certificate of registry.
2. Certificate of classification.(Hull & Machinery)
3. International tonnage certificate.
4. International load line certificate.
5. International load line exemption certificate.
6. Intact stability booklet.
7. Minimum safe manning certificate.
8. Cargo ship safety construction certificate.
9. Cargo ship safety equipment certificate.
10. Cargo ship safety radio certificate.
11. Deratting or Deratting - exemption certificate.
12. International oil pollution prevention certificate.
13. Oil pollution insurance certificate.
14. Certificate of financial responsibility.
15. STCW.
16. Certificate of cargo handling gear.
17. Safety management certificate.
18. Oil record book.
19. Articles of agreements, Port clearance

CARGO SHIP SAFETY CONSTRUCTION CERTIFICATE. (5 years / Annual inspection)

This certificate will issue on satisfactory, inspection of the following items.

1. Ship structure including structural fire protection.
2. Internal examination of ship bottom, cargo and bunker piping system.
3. Boilers, pressure vessel and fittings.
4. Electrical installation.
5. Main & auxiliary machinery and steering gear.

CARGO SHIP SAFETY EQUIPMENT CERTIFICATE. (2 years/ Annual inspection)

Every merchant ship over 500 grt needs a safety equipment certificate. It is issued by the government of the flag state after a survey has shown that the vessel meets the requirement of SOLAS Convention Given to cargo ship covers

1. Life saving appliances.
2. Fire fighting appliances.
3. Navigation lights & equipment.
4. Sound signals & alarm system.
5. Vessel's documentation.
6. Display of fire control plan & life saving appliances plan.
7. Nautical publications.
8. Training manuals.
9. Drills & Test records.
10. Pilot boarding arrangements.

SAFETY EQUIPMENT SURVEY.

Every 2 years interval and annual inspection of its certificate validity $\pm$ 3 months.

1. To run ***lifeboat*** engine both ahead and astern direction, check fuel oil tank & LO sump.
2. To inspect means of illuminating power source for launching (lights) lifeboat and life raft.
3. To swing out lifeboat at least 50% lowered into sea, lowering & hosting device to be kept in good order.
4. To lay out and survey all life boat equipment.
5. Check (LSA) life jacket, life buoy, life raft, and immersion suit, breathing apparatus and fireman outfit.
6. To inspect and test emergency and main fire pumps, keep fuel tank full.
7. To inspect & test emergency generator, emergency battery & emergency lighting system.
8. To inspect &test emergency air compressor and emergency air bottle.
9. To inspect fire hoses nozzles & container box.
10. To inspect all portable extinguisher, nonportable extinguisher, fixed installation system (level of gas, clearing line with compress air, operating system), and alarm system.
11. To inspect audible and visual fire alarms, fire detecting system, abandon ship warning and ship sirens, Muster list.
12. To call for fire drill, boat drills and abandons ship drill.
13. To inspect means of stop switch of E/R for fans, FO pumps, FO & LO tank valves, fire dampers; sky sight door & watertight doors.
14. To inspect latest Nautical publication.
15. To inspect navigation equipment & light.
16. To inspect vessel documentation.

CARGO SHIP SAFETY RADIO CERTIFICATE (1 year)

Issued on satisfactory of inspection on radio equipment on board and in survival craft.

SAFETY CERTIFICATE.

1. Load line certificate.
2. Safety construction certificate.
3. Safety equipment certificate.
4. Safety radio certificate.
5. MARPOL CERTIFICATE(IOPP, ISPP)
6. Certificate of fitness for the carriage of dangerous chemicals in bulk
7. Certificate of fitness for the carriage of liquefy cargo in bulk.

LOAD LINE CERTIFICATE

Valid for 5 years subjected to annual, periodical load line inspection.

LOAD LINE SURVEY

It should be held at 5 years intervals from the date of built and if practicable whenever the periodical special classification survey is made.

During this survey all freeboard items to be examined and load line marking to be verified.

The main purpose of the load line survey is that the ship construction must meet the requirement of the conventions and can be grouped into 4 categories.

1. Structural strength.
2. Weather tight integrity.
3. Stability and
4. Crew quarter protection.

The following item should be inspected.

1. Hatch coaming, hatchway, hatch cover and closing appliances.
2. Ventilators, air pipes and closing appliances, fuel oil tank air pipes and flame trap.
3. Watertight door and stop valve in the watertight bulkhead and closing appliances.
4. Hand rail, catwalk, bulwarks, scuppers of freeing ports, gangway and guard rails.
5. Scuppers and other discharge valves and pipes below the freeboard deck.
6. Cargo ports below the freeboard deck.
7. Exposed engine opening and their closing appliances, engine room skylights and their closing appliances.
8. Opening in the sides and ends of enclosed superstructures.
9. General condition of the hull as far as could be seen.
10. Approved stability booklet.
11. Position of load line mark and deck line.

I.O.P.P SURVEY

5 years interval at least one intermediate survey, not before six months prior to and not later than six months after the half way date of validity of certificate. (MARPOL REGULATION: 4 1.C)

1. Check the validity of certificate.
2. Check the OWS & piping system.
3. Check alarm test and 15 ppm stopping device
4. Check every valves in good order.
5. Filter element spare on board.
6. U.S.C.G Notice should be placed on O.W.S.
7. Check waste oil tank and capacity.
8. Check the fuel consumption.
9. Calculate sludge formation and compared.
10. Check oil record book and prepared up to date.
11. Check incinerator capacity.
12. Sludge tank low & high level alarm test.
13. Certificate of sludge transferred to shore facility.
14. Check the trademark of the maker and it must be approved by I.M.O.
15. Bilge overboard discharge valve must be tight close and kept under chain and lock and bilge direct connection must be blanked by Blind Flange. This connection must be absolutely free from oil and sludge.

PORT STATE CONTROL.

A port state inspection is a particular form of statutory survey. It is carried by a surveyor representing the authorities of the government of the port in which a ship find it self. The intention of the survey is to check that the ship using the port meet with international minimum requirements. The inspection carried out regardless of the nationality of the visiting vessel. At every port where the ship called on, the government body concerned has a right to access to the ship and conduct inspection on the

1. Safety equipment.
2. I.O.P.P certificate.
3. Oil record book.
4. Sewage treatment plant.
5. MARPOL equipment for port state control measured.

1. The international convention of load line.

2. The international convention for the safety of life at sea. (SOLAS)
3. The international convention for the prevention of pollution from ship.(MARPOL 1973/78)
4. The international convention on standard of training certification and watch keeping for seafarers.(S.T.C.W)
5. International regulation preventing collision at sea.(Colag)
6. The merchant shipping minimum standard convention.
7. E/R cleanness & incinerator operation.

(Same as ISM inspection)

P & I CLUB. (Protection & identity club)

Insurance for small damage.
Formed by ship owners to insure certain damage related to ship, which does not cover by insurance policy.

SOLAS	International convention for safety of life at sea
S.T.C.W	International convention for standard of training, certification & watch keeping for seafarers.
GMDSS	Global maritime distress and safety system
I.S.M	International safety management.
S.M.S	Safety management system
D.O.C	Document of compliance
S.M.C	Safety management certificate
I.A.C.S	International association of Classification Society
MARPOL	International convention for the prevention of pollution from ship
SOPEP	Shipboard oil pollution emergency plan

General check list for audit. (ISM code)

1. Certificates and documents including ORB & log book.
2. Safety in general.
3. Testing & drill.
4. Navigation equipment
5. L.S.A
6. F.F.A
7. Radio installation including GMDSS
8. Load lines
9. Hull construction
10. Machinery in engine room
11. Electrical equipment
12. Mooring equipment
13. Marine pollution
14. Cargo gears
15. Accommodation

IACS (International association of classification society)

1.	Registro Italiano Navel	(Italy)
2.	USSR register of shipping	(Moscow)
3.	Lloyd's register of shipping	(London)
4.	Bureau Veritus	(Antwerp)
5.	American Bureau of shipping	(Newyork)
6.	Det Narske Veritas	(Oslo)
7.	Germanischer Lloyd	(Hamburg)
8.	Nippon Kaiji Kyokai	(Tokyo)

What is the purpose of C.S.M?

Instead of opening up for the survey during the class renewal period, all the survey items are equally distributed within the 5 years period for the convenient for the owner. Owner to be requested the classification society to enter the C.S.M.

What included in C.S.M survey?

1. Main propulsion machinery (a) steam turbine (b) diesel engine.
2. Power transmission system and main shafting. (reduction gear)
3. Auxiliary engine.
4. Air compressor.
5. Cooling pumps.
6. Fuel oil pumps.
7. L.O pumps.
8. Feed water pump, condensate pump, drain pump.
9. Bilge, ballast and fire pump.
10. Condenser and heater. (feed water)
11. Coolers & Oil heaters.
13. F.O tanks.
14. Air receivers.
15. Deck machinery.

Items not cover by C.M.S.

1. Propeller and propeller shaft.
2. Sea valve below lead water line.
3. Boiler, economizer, thermal oil system.
4. Cargo handling equipment.
5. Measurement of crank shaft deflection.
6. Sterntube wear down measurement.
7. Rudder bearing and pintle measurement.
8. Performance and pressure test.
9. Special equipment design.(proto type, etc)
10. Small capacity & low operational frequency equipment.
11. Foundation bolt.

BOTTOM SURVEY

1. Shell plating.
2. Propeller.

3. Rudder.
4. Stern frame.
5. Tail shaft, propeller shaft.
6. Stern tube bearing, gland.
7. Sea valve, chest.
8. Grids, scupper.
9. Cathodic protection.
10. Anchor cable layout & wear down.

FIRE CONTROL PLAN

1. Control station
2. The various of fire section enclosed by class A & B division.
3. Fire detecting and alarming system.
4. Sprinkler installation & fire extinguish appliance.
5. Means of escape
6. Ventilation system(position, damper, no: of fan control)

FLAG STATE CONTROL.

The administrations have responsibility of the ship built to their flag commonly with the requirements of the conventions in construction and up keep after wards.

For this intention the government body carried out surveys and issued certificates relating to the shipping industry includes.

1. Passenger ship safety certificate. (1yr)
2. Cargo ship safety construction certificate.(5yr)
3. Cargo ship safety equipment certificate. (2yr)
4. Cargo ship safety radio certificate. (1yr)
5. Exemption certificate.
6. International load line certificate. (5yr)
7. MARPOL certificate
   IOPP, oil record book & ISPP
   (5yr)

SPECIAL AREA

1. Mediterranean sea, Baltic sea, Red sea, Black sea & North sea
2. Gulf of Aden, Persian Gulf
3. Antertic Area, Wider Caribbean Area

(Other sea area & many inland water way)

OIL RECORD BOOK (LIST OF ITEMS TO BE RECORDED)

1. **Ballasting and cleaning** of oil fuel tanks.

Date, Identity of tanks, Last contain oil, Cleaning process (position of ship & time @ the start & completion)

2. **Discharge** of dirty ballast or cleaning water from oil fuel tank refer to under section 1.

Date, Identity of tanks, Position of ship at start & completion, Ship speed, Method of discharge, Quantity of discharge.

3. **Collection & disposal** of oil residues.(**sludge**)

Date, Identity of tanks, Total quantity of retention

Date, Method of disposal, Quantity of disposal & retained.

4. **Non-automatic discharge overboard** or disposal otherwise of **bilge** water which has accumulated in **machinery space**.
5. **Automatic discharge overboard** or disposal otherwise of bilge water which has accumulated in machinery space.

Date, Quantity, time & position of ship @ start & completion, Method of discharge.

6. Condition of **oil discharge monitoring and control system.**

Date,Time of system failure & Operational, Reason.

7. **Accidental or other exceptional discharge** of oil.

Date, Time, Place, Quantity, Reason.

8. **Bunkering** of fuel (or) bulk lubricating oil.

Date, Place, Time of start & completion, Type & Quantity(added & total)

9. Additional operational procedures and general remarks.

MARPOL (73/78)

Annex I Regulation for the prevention of pollution by ***oil***.
Annex II Regulation for the control of pollution by ***Noxious Liquid substances***
Annex III Regulation for the prevention of pollution by ***Harmful substances*** in Packaged forms
Annex IV Regulation for the prevention of pollution by ***sewage.***
Annex V Regulation for the prevention of pollution by ***Garbage*** from ship.

SLUDGE AMOUNT.

1 to 2 % of fuel consumption.
At least 1 % of fuel consumption.

TO CHECK FIRE ALARM - Tested by smoke detector.

TO CKECK CO_2 ALARM - Tested by CO_2 cabinet box

OIL RECORD BOOK

Record to be kept on board for the operation of oily water, Sludges & bunkering.

ATTACH WITH OIL RECORD BOOK

1. Photo copy of MARPOL certificate.
2. Original oil disposal certificate.
3. Dirty oil & sludge piping diagram.

BILGES PUMPING OUT CRITERIA.

- In port not allow

OUTSIDE SPECIAL AREA	*WITHIN SPECIAL AREA*
1. Vessel enroute 2. Oil particle less than 15ppm 3. Has an operational oil discharge monitoring system, oily water separator.	1. Vessel enroute 2. Oil particle less than 15ppm 3. Has an operational filtering equipment with automatic stopping device.

BREATHING APPRATUS CAPACITY.

- At least 30 mins for hardworking.
  45 mins for light working.
- 1200 lit

Boiler survey

- Every 2 years up to 8 years after built.
- Every year, after 8 years.

Annual survey

The annual survey requires a general inspection of the whole machinery and equipment.

Periodical survey

The periodical survey requires a thorough inspection and include performance test and inspection of electrical installation etc:

Classification Societies.

Classification Societies are third party independent bodies whose function is to ensure that a ship is soundly constructed and that the standard of construction is maintained. They also carried out the statutory surveys on behalf of the Administrations according to the various international regulations and codes relating to ship safety and prevention of pollution of marine environment.

Classification of the ship enables :-

1. The insurers to assess the premium relative to the ship (hull insurance) and cargo (cargo insurance).
2. The owner to find an insurer who accepts to cover the risks incurred by the ship.
3. The owner to charter his ship.
4. The charterer to select advisedly the ship whom he will entrust with his cargo.
5. A future owner to assess the quality of the ship prior to the purchase.
6. The flag authorities to trust the ship and therefore to register her into their fleet.

Classed ships

Upon confirmation of their compliance with the requirements of the Rules through classification surveys by the surveyors, the ships are entitled to a class appropriate to their types and to the services on which they are engaged. For the ships entitled to a class, the classification societies issue a Classification Certificate which confirms that the ships have both structural and mechanical fitness for their intended services.

Maintaining the class

By owners carrying out regular surveys of the hull, machinery and equipment, as well as repairs that may be required from time to time as a result of wear and tear or accident, all under the supervision of classification of classification surveyors. The class is granted generally for a term of five years during which its validity is subject to compulsory periodical surveys.

Statutory surveys

Statutory surveys are differ from classification surveys in that they are not assessing or measuring something for a client. Statutory survey is simply inspecting something against a set standard or law. On completion of his survey, he issues the ship with a certificate which is essential to the ship's ability to trade. It is issued on behalf of the government and has a legal, international status.

Fire hose & nozzle required for a ship.

At least two numbers of hose & nozzle from fire hydrant can reach any part of the fire hazard on board ship.

Fire fighting equipment for machinery space.

1. Portable fire extinguisher (CO_2, Foam, Dry power)
   - Capacity 9 liter, not more than 13.5 liter,
   - At least two numbers at every 10 m walking distance.
2. Non portable (Foam)
   - 2 numbers (Boiler room & Machinery space.)
   - Capacity 45 liter.
3. Fixed installation.(CO2, Foam, Pressure water)
4. Sand box & Scoop.

Personal life saving appliance.

1. Life jacket.
2. Life buoy.
3. immersion suit.

Emergency & safety drill @ sea.

- For safety of ship, crew & cargoes.

Saturday routing.

1. Fire drill.
2. Emergency fire pump operation.
3. Fire detector, alarm & sound signal.
4. Emergency generator operation.
5. Life boat drill
6. Check life boat engine & test run both ahead & astern direction.

LIFE SAVING APPLIANCES.

1. Life boat, life raft, life buoy, life jacket.
2. First aid kit.
3. Compass.
4. Line throwing appliance.
5. Life boat radio with 2 way V.H.F system.
6. Life boat engine & food ration.
7. Fire fighting equipment.
8. Immersion suit for every crew of rescue boat & thermal protective aid.
9. Rador responder of two numbers on each side of ship.
10. Muster list & emergency instruction.
11. Rescue boat.
12. Survival craft embarkation & launching equipment.
13. General emergency alarm system and P.A system.

Fire mans outfit

1) Protective clothing.
2) Boots and gloves. (electrically nonconducting material)
3) Rigid helmet.
4) Electric safety lamp. (min: burning period 3 hours)
5) Axe
6) Life line.
7) Breathing apparatus.

Underwriter.

A person who insures the whole or a part of a ship or its cargo.

Underwriter surveyor.

A person recognized by insurance company who is witness of insurance company for insurance claiming.

Damage survey

Damage to hull, machinery or equipment, which effects or may effect seaworthiness of classification, is to be submitted by owners or their representatives for examination of the surveyor. All repairs found necessary by the surveyor are to be carried out to his satisfaction.

Pre-loading survey

Pre-loading surveys of refrigerated cargo installation are also conducted at the request of the owners / charterers for the loading of the refrigerating machinery in working condition and inspection of the refrigerated cargo compartments are to be made prior to loading of intended refrigerated cargo.

Surveys relating to merchant ships in service.

Part A - Classification surveys

1. Annual survey, special survey and continuous survey (Hull and Machinery)
2. Boiler survey
3. Dry docking survey
4. Tail shaft survey
5. Shipboard automatic and remote-control systems survey
6. Refrigeration plant survey
7. Damage survey

Part B - Statutory surveys

1. Load line survey
2. Safety construction survey
3. Safety equipment survey
4. Safety radio survey
5. MARPOL surveys
6. Tests, examinations and inspections of ship's cargo handling machinery and gear.

Part C - Surveys requested by authorities, charterers, owners, underwriters, etc.:

1. Damage survey
2. On/off hire survey
3. Laid up ship survey
4. Surveys according to IMO codes
5. Pre-loading survey
6. Draught survey
7. Conditional survey

SAFETY EQUIPMENT SURVEY. (As a C/E)

Every 2 years interval and annual inspection of its certificate validity ± 3 months.

1. To run ***lifeboat*** engine both ahead and astern direction, check fuel oil tank & LO sump.
2. To inspect means of illuminating power source for launching (lights) lifeboat and life raft.
3. Lowering & hosting device to be kept in good order.
4. To inspect and test emergency fire pump (keep fuel tank full) and main fire pumps,
5. To inspect & test emergency generator, emergency battery & emergency lighting system.
6. To inspect & test emergency air compressor and emergency air bottle.
7. To inspect audible and visual fire alarms, fire detecting system.
8. To inspect trips, means of stop switch of E/R for fans, FO pumps, FO & LO tank valves, fire dampers; sky sight door & watertight doors.

Class survey.

Class survey is to ensure that a ship is soundly constructed and that the standard of construction is maintained. (Goal is sea worthiness)

Unclass ship can enter or departure from the port but statutory survey is strict for unclass ship.

At sea garbage disposal requirements

Garbage type	Outside special area	In special area
Plastics - Includes synthetic ropes and fishing nets and plastic garbage bags.	Disposal prohibited	Disposal prohibited
Floating dunnage, lining and packing materials.	> 25 miles off shore.	Disposal prohibited
Paper, rags, glass, metal, bottles, crockery and similar refuse.	> 12 miles	Disposal prohibited
All other garbage including paper, rags glass, etc. comminuted or ground.	> 3 miles	Disposal prohibited
Food waste not comminuted or ground.	> 12 miles	> 12 miles
Food waste comminuted or ground.	> 3 miles	> 12 miles
Mixed refuse type	***	***

*Comminuted or ground garbage must be able to pass through a screen with mesh size no larger than 25 mm .

Big end bearing removing and fitting procedure.

1) *Take immobilization from port authority*
2) *Close main air stop valve and lock starting system*
3) *Engage turning gear and stop L.O pump*
4) *Open crankcase door*
5) *Turn crankshaft until the crank is BDC*
6) *Measure bearing clearance by inserting feeler gauge between bearing lower half and crankpin.*
7) Turn the crank shaft to TDC position.
8) Remove locking arrangement and slackened the nuts. The bottom half lower a few and took out bearing clearance adjusting shim, each set being tied separately and note taken of the side to which each set belongs.
9) Chain blocks connected to eye bolts, screw into each bolt. After removing two nuts, bottom half lowered into the sump. Putting hanging bar in position, connect chain blocks to crankcase door frame and eye bolts which is screwed into each side of the top half. Then turn the crankshaft to the position where the top half can be taken out.
10) Also take out the bottom half with bolts outside the crankcase

11) Inspection on crank pin, bearings, oil holes, grooves, bolts cracks, sign of movement and elongation.

11) Take measurements of crank pin at least 3 place top, bottom and port, stb check ovality.
12) Display surveyor, check points are
    - 12a) Bearing clearance (0.5 to 0.7 mm for 550 mm diameter crank pin)
    - 12b) Bearing surface (No crack, no damage and if wipe out 30% renew it)
    - 12c) Check holding down bearing surface.
    - 12d) Oil hole and grooves (No damage)
    - 12e) Crankpin ovality and its surface
    - 12f) Lubricating system (clear)
    - 12g) Big end bearing bolts (Good thread, no extension, no cracking and no twisting)
    - 12h) heck sign of movement of the joint point such as two halve of bearing joint and between top halve and connecting rod foot.

What points to be checked after removing big end bearing ?

- After cleaning, inspect the bearing thoroughly at crank pin ovility and two halves of bearing surface (wear, crack and damage) together with oil holes and grooves. (If over 30 % of wear or crack in the contact area it should be renewed)
- Thoroughly, examined the bolts for cracks in the threads (no extension and no twisting)
- Check sign of movement of the joint point such as two halve of bearing joint and between top halve and connecting rod foot.
- Bearing clearance.
- Check holding down bearing surface.

Fuel valve cooling

All fuel valves need proper cooling to maintain the tip region temperature within acceptable zone to avoid malfunction of the operation mechanism. The cooling is insufficient may result:

Cracking of fuel oil leading to clogging of sprayer holes, sticking of needle valves and wearing and distortion of sprayer holes.

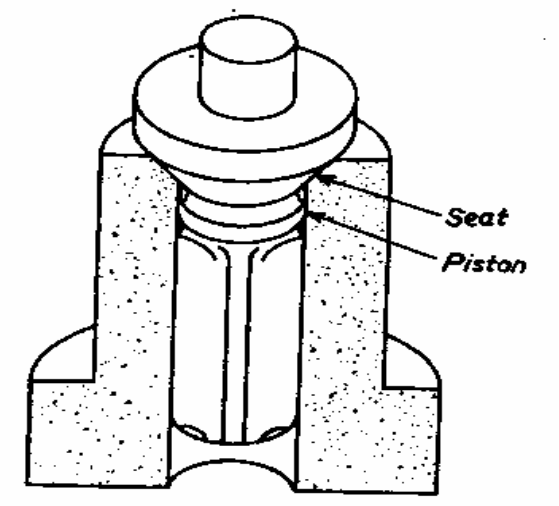
Carbon trumpets formation of or carbon petal formation on the tip around the sprayer holes.

Over cooling may result; Low temperature corrosion, insufficient flow quantity and too high degree of penetration.

Anti dribbling arrangement

As the valve closes at the end of pumping, the piston section of the pin, or unloading collar, enters the valve seat bore to extract a small amount of fuel from the high-pressure line before the valve is completely closed.

This extraction causes a negative pressure wave which travels along the fuel line to the nozzle and ensures that the nozzle valve closes rapidly to give a sharp cut-off to the end of the injection, to prevent dribble and secondary injections.



Shipboard Oil Pollution Emergency Plan: SOPEP.

Every oil tanker of 150GRT and above, and every ship of 400GRT and above, shall carry onboard a Shipboard Oil Pollution Emergency Plan.

The plan shall consist at least of:

01) *Procedures* to be followed by Master, or other person having charged of the ship, *to report an oil pollution incident*.

02) *List of authorities or persons to be contacted*, in the event of oil pollution incident.

03) *Detailed description of actions* to be taken immediately by persons onboard, to reduce or control the discharge of oil.

04) *Procedures and point of contact onboard*, for co-ordinating shipboard action with local authorities in combating the pollution.

SOPEP Requirements:

Oil spill kit inside Oil spill Locker:

Can be grouped into: **Solvent** **Absorbent** **Cleaning** **Plugging material.**

01) OSD 200 litres.
02) Chemical splash suit 10 nos.
03) Goggle 10 pairs.
04) Boots 10 pairs.
05) Nitrile gloves 10 pairs.

---

06) Sawdust and cotton rags.
07) Oil seals 30 nos.
08) Oil coushions 40 nos.
09) Oil scoop (non-spark) 1 no.

---

10) Deep pan shovel (non-spark) 1 no.
11) Disposable bags 10 nos.
12) 29 ft^3 Container 2 nos.
13) Bucket (non-spark) 1 no.
14) Brooms 6 nos.

---

15) Scupper plugs
16) Cement for plugging
17) Submersible pump (Wilden)
18) Bilge and Ballast Piping Diagram.
19) Fuel and LO system Piping Diagram.
20) HO responsible address.
21) Port Authority Address.
22) Agent Address.

Procedures, when accidental oil overflow occurs:

1. Notify Harbour/Terminal Authority immediately through the Master.
2. Actions immediately taken by persons onboard to *stop, reduce* or *control* the oil discharge.
3. Co-ordinate shipboard actions with local Authorities.
4. Inform owner, agent, P&I Club, Flag State Authorities, and vessels in vicinity.
5. Invite P&I (Protection and indemnity) correspondents.
6. Record in ORB, time & place of occurrence, approximate amount & type of oil, circumstances of discharge or escape.

Bridge gauge

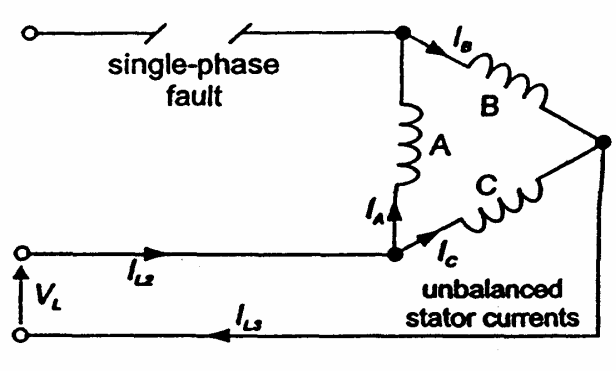
A bridge gauge enables the measurement of journal bearing wear down with the crankshaft in place.

Top half of housing must be removed and the gauge place on the butt face of the bottom half bearings. The feeler gauge is inserted between the journal and the apex point and readings recorded and compared with the previous and the original recorded and compared with the previous and the original results.

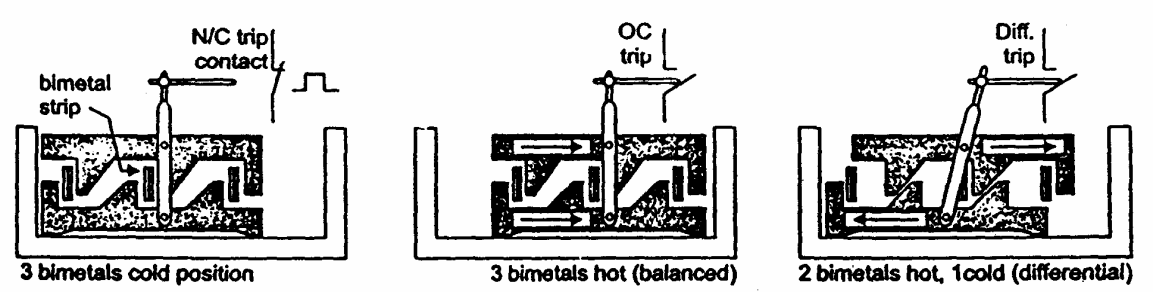
For journal ovality, the crankshaft turned through 30° or 45° interval for each successive measurement. (All results must be the same, if not journal is ovality).

Single Phasing

Single Phasing means that ***one of the three phases of the motor is disconnected***. If a motor is already running, and this occurs, it may lead to excessively high currents and eventual burn-out of the motor.



This situation can take place if *one of the back-up fuses blows or a Contactor is open circuited.* The currents in the remaining lines increase and the torque becomes uneven, besides causing excess current through the remaining phases. The three thermal elements of an ***Over current relay*** (OCR) can detect un-equal heating due to this situation, which trips the motor Contactors.



As seen in the sketch, the contacts are normally closed (NC). If there is excess current, all the three bimetallic strips move to the right, to operate the trip due to over-current. In case of single phasing, the current through the remaining lines may not be sufficient to operate the trip, however, the single bimetallic strip, of the line which is open-circuited, remains on the left (in the last sketch), which causes the upper and lower parts to shift relative to each other, and the resultant movement causes the trip to operate.

For larger motors, a separate device called *a negative phase sequence relay is used*, to measure the unbalance between the currents.

A stationary motor will not re-start when single phasing occurs.

MAINTENANCE

Cleaning of sea water side and oil side is at regular interval. After cleaning, the coolers are hydraulically pressure tested about a little more than its Working pressure. If the 10% of the tubes have been leaked, retubing is necessary. Normal leaking tubes may be stopped by plugging.

In surveying the L.O cooler, the following points to be checked;

(01) Test pressure and any leak points under test.
(02) Check division plate (holes)
(03) Numbers of plugged tubes
(04) Condition of water boxes and anodes for wear
(05) Condition of shell for heat transfer surfaces, Vent plug and drain plug.
(06) Condition of Safety leakage ring
(07) Condition of tube plate surfaces for pitting corrosion
(08) Total removal of tube stack and inspect inside the shell and baffles for any wastage and pitting corrosion and cleanliness of heat transfer surfaces.

Steering gear / Stern tube / Rudder

1. How to know power of steering motor ? (*Power test/Swing test)*
2. How will you carry out steering ger test, what are the purposes of swing test ?
3. When telemotor failure what will you do ? 6/63
4. Checking of steering gear room 66
5. What are the daily checks in steering gear room ? 66
6. *How to check leakage of stern tube oil ?*
7. How to measure rudder wear and when ?191
8. How will you measure stern tube wear down ? 188/190
9. State function of hunting ?2/63

Explosion

a How to prevent crank case explosion ? 14/85
a State maintenance of oil mist detector . 28/89
a How is crank case explosion occurred?
a What are the safety devices for crank case explosion ?
a How to check crank case relief door ?
a What are the requirements of crank case relief door ?
a Why does air line explosion occur ?
a Say prevent for air line explosion.
a What are the safety devices ?
a How can you detect leaking air staring valve at sea and in port ?
a How do you carry out safety cap maintenance ?

Air bottle and compressor

a What are the air bottle safety devices ?
a Carry out air bottle pressure test.
a State air compressor safety device ?
a Why 1st and 2nd state relieve valve of air compressor open ?
a Where is fusible plug fitted ?
a Why is fusible plug fitted ?
a What are the purposes of bursting disc ?
a Why intercooler is fitted to air compressor ?
a State function of inter cooler ?
a How to know air cooler leakage ?
a Operate main air compressor by manually ?
a Air compressor busting disc and relief valve different operation and can be used in the same place.
a To get good performance of air compressor.
a How to know efficiency of air compressor is good or not ?
a What is bumping clearance, effect when less and more ? Why it is important ?
a Why compressors used in marine are multiple states ?

Indicator Diagrams

a Do you know how many kinds of indication cards ?
a Why power diagram is taken ?
a How will you take power diagrams ? How do you calculate its ?
a Why is draw card taken ?
a Why light spring card is taken ?
a If you don't have Planometer how will you calculate area of power diagram ?

Boiler

a Are there how may kinds of boiler safety valve ?
a How to set boiler safety valve pressure ?
a How do you understand boiler flash-up ?
a Flash-up procedure
a Boiler mounting.
a What is back fire ?
a If you find oil in boiler, what will you do ?
a If you found oil in the feed water tank, Why has in it ? what will you do ?
a Carry out boiler gauge glass blow down.
a Carry out scum blow down.
a How can you know exact boiler water level ?
a Cause of boiler corrosion.
a Boiler Foaming, priming and water hammering.
a Boiler water contamination.
a Safety vale pressure setting procedure.
a Soot blower maintenance.
a There are excess chloride in boiler water, what will you do ?

- Why take T-Alkalinity in boiler water test ?
- Explain about waste heat recovery system ?
- What will you do steam excess in economizer ?
- How to control steam generation of economizer ?
- When is soot blowing carried out and why ?

Fuel Oil System

- What are the settling tank mounting ?
- What type of drain valve is used in settling tank ? *Self-closing type*
- Say, how many kinds of fuel valve tests, how to carry out dripping test ?
- How would you perform fuel valve test ?
- What will you check when you overhaul fuel injection pump.
- Fuel pump timing checking.
- How will you check leakage delivery valve ?
- Fuel pump metering.
- What is V.I.T ?
- How would you prevent antidribbling ?
- State F.O specification at bunker ?
- Explain F.O pour point ?
- How to check oil tank leakage ?
- What is the flash point ?
- How to clean duplex filter ?

Refrigeration

- How do you check leakage of refrigeration.
- What is refrigerant ?
- Sate properties of refrigerant ?
- What / Why is critical temperature important?
- What effects will occur, if air in the refrigeration system ?
- What are the operational faults of overcharge ?
- What are the effects of moisture in the refrigeration system ?
- Explain function of back pressure valve ? Location.
- Carry out air purging of refrigeration system ?
- Refrigeration safety devices ?

Pollution

- State regulation of sewage disposal ?
- regulation.
- State garbage regulations.
- What/Explain is bilge injection valve ?

Fire and Safety

- How to enter into the fuel oil empty tank ?
- Enclose space, F.O service tank entering procedure .
- Cause / How to prevent scavenge fire ?
- Explain Uptake fire ?
- How many methods of fire extinguishing ?
- Say, five items of fire fighting media ?
- How do you extinguish with CO_2 portable extinguisher?
- What are the fire man outfits ?
- How to extinguish oil fire with water ?
- What type of fire can be extinguished by Soda-Acid P.F.E ? (*Carbonaceous material*)
- How to use foam extinguisher, why deflection is carried ?
- Where is quick closing valve fitted and why fitted ?
- What is the international shore connection ?
- Do you understand fixed installation ?
- What is SOPEP ? State equipment of SOPEP ?
- What is emergency fire pump ? Capacity ?
- How will you check once a week for smoke detector ?
- What will cause if CO_2 cabinet door is opened ?
- What do you check for CO_2 fixed installation system ?
- CO2 room safety device.
- Economizer fire fighting / How to prevent Economizer fire ?
- Cargo hole fire extinguishing by CO_2
- Foam portable fire extinguisher no spray, what will you do ?
- How many type of fire detector ?

Turbocharger

- What do you check during T/C overhaul ?
- How to wash T/C turbine side ?
- Carry out T/C water washing
- State action to be taken for T/C surging.
- State measurements to be taken during T/C overhauling.

- State purpose of axial clearance.
- State scavenging system and explain loop scavenging system.
- Are there how many kinds of exhaust system ? State advantages of constant pressure.
- Say, three kinds of scavenging system ? How does cross-flow work ?
- Difference constant and pulse .
- Explain turbocharger surging ?
- Why installed the T/C header tank ?

M/E

- How to carry out liner calibration ? How much wear down limit ? (1% of original dia)
- How to get main bearing clearance ?
- What will you check thin shell bearing for further use ?
- Say, how much normal clearance for main bearing of diameter 500 mm.(550 dia – 0.8 mm max.)
- State survey procedure for M/E main bearing & measurements to be taken ?
- Explain crank pin bearing ?
- Overhaul Cross head
- Carry out cross head survey.
- What will you do in cause of high temperature at intermediate bearing ?
- ***If thrust bearing is high, what will you do ?***
- What are the cause of connecting rod big end bearing failure ?
- What will you check for piston crown ?
- How to carried out pressure test in piston overhauling ?
- What will you check at plumber block ?
- What is purpose of thrust block ?
- How to overhaul stuffing box ?
- Governor drop.
- Governor function.
- Function of mechanical governor.
- Why over speed trip is fitted in additional to the governor ?
- What are the cause of high exhaust temperature ?
- How to overhaul lubricator quill ?
- State maintenance for lubricator quill. After fitting how to test ?
- What is the critical speed ?
- State difference between over speed trip and governor.
- State difference between Duplex filter and magnet filter.
- What will you do in cause of leakage of generator engine air cooler ?
- M/E chain elongation maximum allowance and checking ?
- How would you take crankshaft deflection ?
- Why take Crank shaft deflection ?
- What will you check during crank case inspection ?
- How do you overhaul rotor cap of exhaust valve ?
- Unit overhaul piston & liner check point
- What in the tappet clearance ? Why take ?
- Piston ring clearance (1) Gap – 3 times of original (2) Vertical 0.2 – 0.
- How will you know unbalance of M/E ?

Pump

- How to control discharge pressure of positive displacement pump ? *By pass relief valve*
- Overhaul reciprocating pump ?
- What will you check in screw pump ?
- Why does not ballast pump discharge ?
- Why vacuum is created in bilge pump ?
- What is cavitation ?

Metal

- What is fatigue failure ?
- Stress relieving, why, how ?
- Annealing explain it ?
- Case hardening ?
- Explain welding defects and explain under cut.

Purifier

- What will you check for purifier over flow ?
- Explain purifier overflow.
- Why purifier cannot reach its rated rpm ?
- Purifier bowl high measuring procedure. Why take the bowl high ?

Heat exchanger

- How to check efficiency of heat exchanger ?

- What will you check after cleaning of cooler ?
- How to know L.O cooler leakage while engine running ?
- How to take L.O sample ?
- How to make batch purification ?
- L.O contamination test
- If 100% vacuum is created in Fresh Water Generator, what will cause ? How mush shell temperature of FWG ?

- As a second engineer, state precaution to be taken at rough sea ?
- Explain duties of 2/E
- How will you check plumber block at sea ?
- What are the safety devices of life boat ?
- Explain about statements written in Oil Record Book.
- Are there how many kinds of drill ?
- How to clean sea chest strainer ?

Electro technology

- Explain the earth fault lamp ?
- How will you detect earth faults ?
- How to control speed of AC motor ?
- How to control of DC motor ?
- What will you check in failure of motor ?
- What is the AVR ?
- What is the synchroscope ?
- What are the safety devices for generator engine switch board ?
- What are the safety devices for M/E switch board ?
- State machineries of equipments supplied by emergency switch board ?
- What is essential load ?
- Explain about preferential trip ?
- State single phase on motor.
- What is dash pot ?
- Explain about Megga test ?
- How to run two generator in parallel ?
- Power factor

Naval Architecture

- Where is load water line marked ?
- What is GRT ?
- What is duct keel ?
- Explain about balance rudder ?
- Explain overall length and length between perpendicular.
- How to calculate propeller sip ?
- What is camber ?
- What is the free board ?
- How to check water tight door is fully closed or not ?
- Docking plan